TELESCOPE MAKING 8

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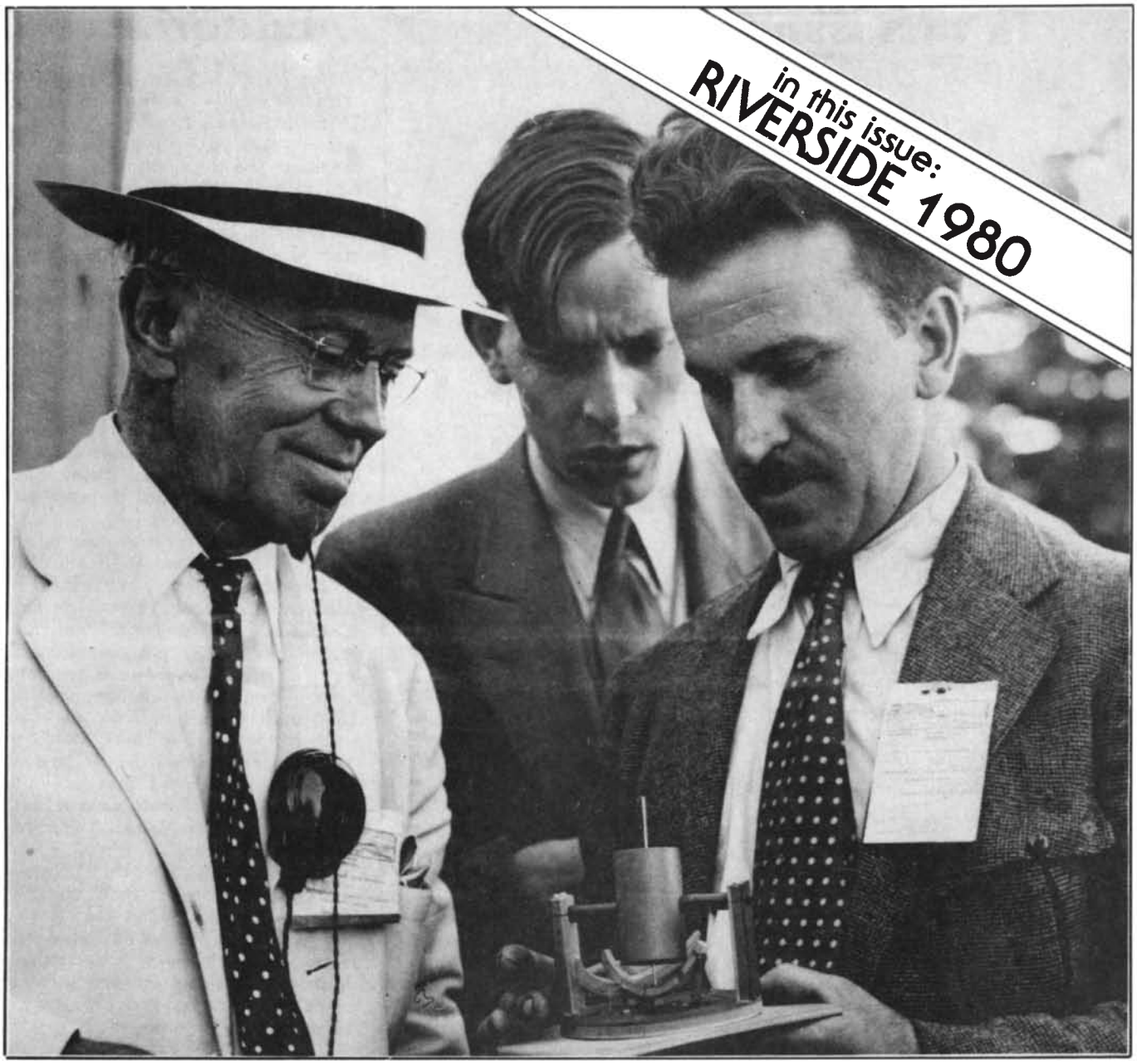
The magazine *for*, *by*, and *about* telescope makers!

Summer 1980



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TELESCOPE MAKING

The magazine *for, by* and *about* telescope makers!

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Cover photo: Russell W. Porter, left,examines a model telescope mounting (brought by a delegate to the 1937 Stellafane meeting) which uses a mechanical coupling to turn altazimuth motion to equatorial tracking. Examining the model with him are Lou Lojas, right, and Ed Hanna of the New York Optical Division of the AAA. Photo by R.E. Cox. Note Mr. Porter's hearing aid: a far cry from today's compact ones.

Editorial

It's renewal time for many of our 2,000 TM readers. The letters I've been getting indicate that you're happy with the magazine, and the warm response I've received at this year's Riverside and last year's Stellafane meetings confirms that TM is making its mark on the hobby and practice of telescope making. As you did last year, I hope that once again a generous percentage of you will renew your subscription for another year (or preferably two years — there's less paperwork involved) if there is a renewal notice stuffed in the envelope with your copy of the magazine. Please don't forget to renew or overlook it — we won't keep on sending notices *ad nauseam* — now is the time to sit down and do it. Remember that TM, and TM's future, depends on your continuing support.

Item 2: You may have seen our ad in *Sky and Telescope* and ASTRONOMY for a booklet entitled: "How to Build a Dobsonian Telescope." If you're a TM subscriber, I just want to tell you that you've already seen almost everything in that booklet. The major items are Bob Kestner's two articles, one little one from TM#4 and a big one from TM#5, plus the article on the 20-inch in TM#7, a few bits of last year's Riverside report, and a selection of pictures that haven't appeared in TM itself, but sooner or later will. The demand for this information has been slightly frantic. Anyhow, it's a bargain at $2.95, since most hobby publications sell for a lot more (look in a hobby shop sometime!).

Item 3: By the way, we are interested in submissions dealing with electronics as applied to telescope building, from drive control circuits, through micros, to calculator ray-trace programs.

Item 4: We don't pay a whole lot for articles, but the $10 we do pay, the glory of it all, plus a few complimentary copies, seem to make the effort worthwhile.

Item 5: I hope once again to see some of you (the Eastern contingent) at Stellafane, but I can't guarantee I'll make it this year. Things are scheduled pretty tight with ASTRONOMY, and I have an awfully busy Fall coming up.

Sincerely,

Richard Berry

Letters

Astrofest

The Racine Astronomical Society and the Chicago Astronomical Society are pleased to announce the first annual Midwest Astrofest & Telescope Faire, a gathering for telescope makers and observers.

Our hope is to provide a yearly forum for the exchange of ideas and experiences in amateur telescope making and observing, and at the same time, a pleasant weekend outing with congenial people.

But our prime concern is to have as many amateur-built telescopes on display as possible!

The event will be held at the Modine-Benstead Observatory of the RAS, Friday night thru Sunday morning, September 5-7, 1980.

Anyone interested in attending should write to the undersigned for a registration and information packet.

John Allseits
Astrofest Chairperson, RAS & CAS
800 E. Allanson Rd.
Mundelein, IL 60060

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Dear Mr. Berry / In TM #6, Willmann-Bell, Box 4626, Springdale, CT 06907 is given as the supplier of Cera-Hex-Tol, 1"-square hexagonal ceramic tiles. Please print our correct address in the next issue; it would help your readers. We have several customers who have been able to get our current address from other sources, but they told us that they wrote to the Connecticut address first and had their letters returned. Our address is:

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— *Oops!*

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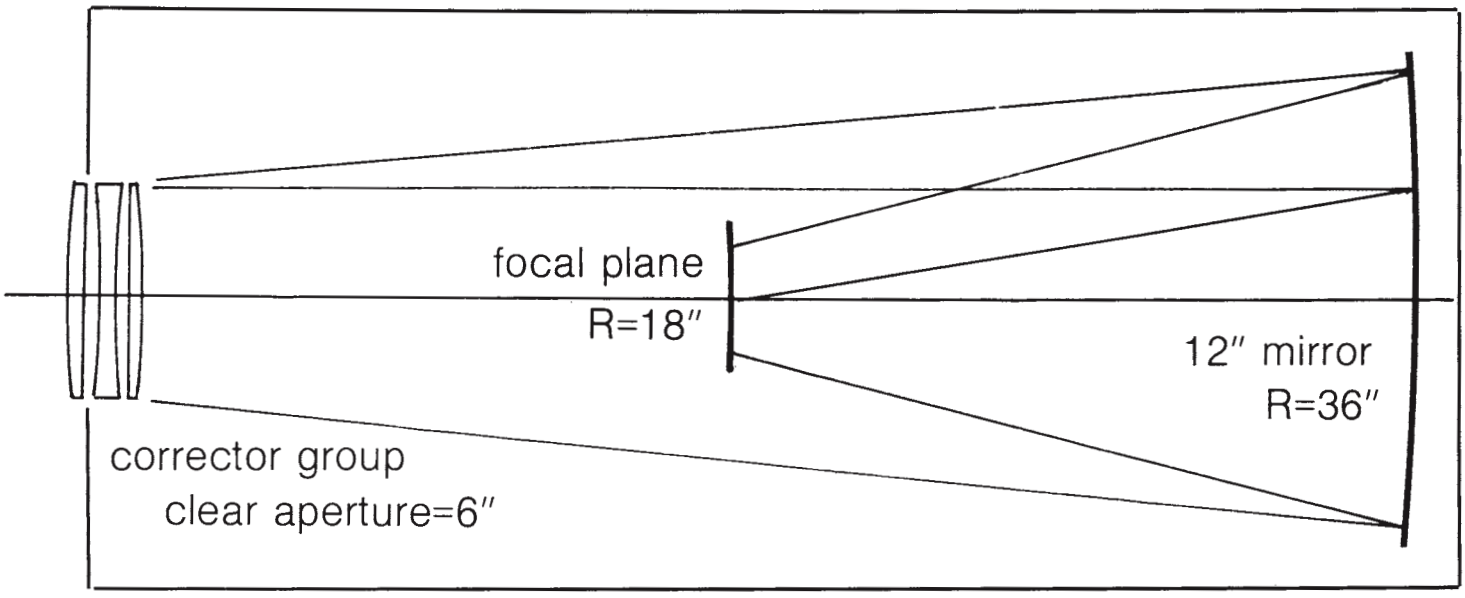


The Houghton Camera

The Houghton camera is an all-spherical substitute for a Schmidt camera. This particular design, computed by the writer for the greatest simplicity in construction with an amateur's optical fabrication methods, lacks the perfection possible in a fully-optimized design (see James L. Houghton's 1944 patent #2,350,112), but it is quite satisfactory for general astrophotographic use. Due to the simplifications in the design (i.e., all curvatures equal), the color is a bit under-corrected, but oblique spherical aberration is only about 25% worse than that of a comparable true Schmidt. If the full Houghton design is attempted, it can surpass true Schmidts in performance, and in particular it can surpass Schmidt-Cassegrain optics.

The advantage of the Houghton over the Maksutov, which also uses only spherical curves, is that the field correction is superior and tolerances are much more lenient. In a Maksutov, you obtain correction for spherical aberration as the differential between the front and rear surfaces of the meniscus lens. The nearly concentric design of the lens minimizes the astigmatism in the field. However, the fact that the lens is non-concentric (in order to be achromatic) means that it cannot avoid off-axis aberration.

The Design

In the Houghton system, the mirror focuses the light and the aberration correction "work" is done by the curvatures of the lenses. The lens thicknesses, consequently, are no more important than the air spaces. If the lenses were infinitely thin, and if the curves didn't bump into each other, the performance of the Houghton would be identical to that of the true Schmidt. But even with the thick lenses, the difference is not great.

Color is self-canceling because the net power of the corrector group is zero. Field aberrations, as in the Schmidt, are canceled (to the third order) by the symmetry of the design. As in the Schmidt, it is limited by an aberration known as "oblique spherical aberration" (also known in some quarters as cubic astigmatism), for which we have no convenient cure.

Nominally, the design is computed for BK7, but any kind of glass may be directly substituted so long as both lenses are the same kind of glass. By grinding the lenses against each other, all with the same curve, the color is automatically canceled. Unless you go to some quite peculiar glass, the change in refractive index will be either negligible, or can be canceled by re-adjusting the air gaps.

The curves which are ground against each other should be assembled opposite each other. This automatically cancels coma in the corrector group, regardless of mismatch in the ordinary curves. If you see coma in the assembled unit, you need only respace the entire corrector unit with respect to the mirror; by this means, any error in coma can be corrected completely.

If the assembled unit shows undercorrected spherical aberration, the lenses can be spaced more closely. If overcorrected, increase the air gap between the lenses. This is something you can't do with a Maksutov, and it's a decided advantage if you want a well-corrected system without repeated reworking of the optics.

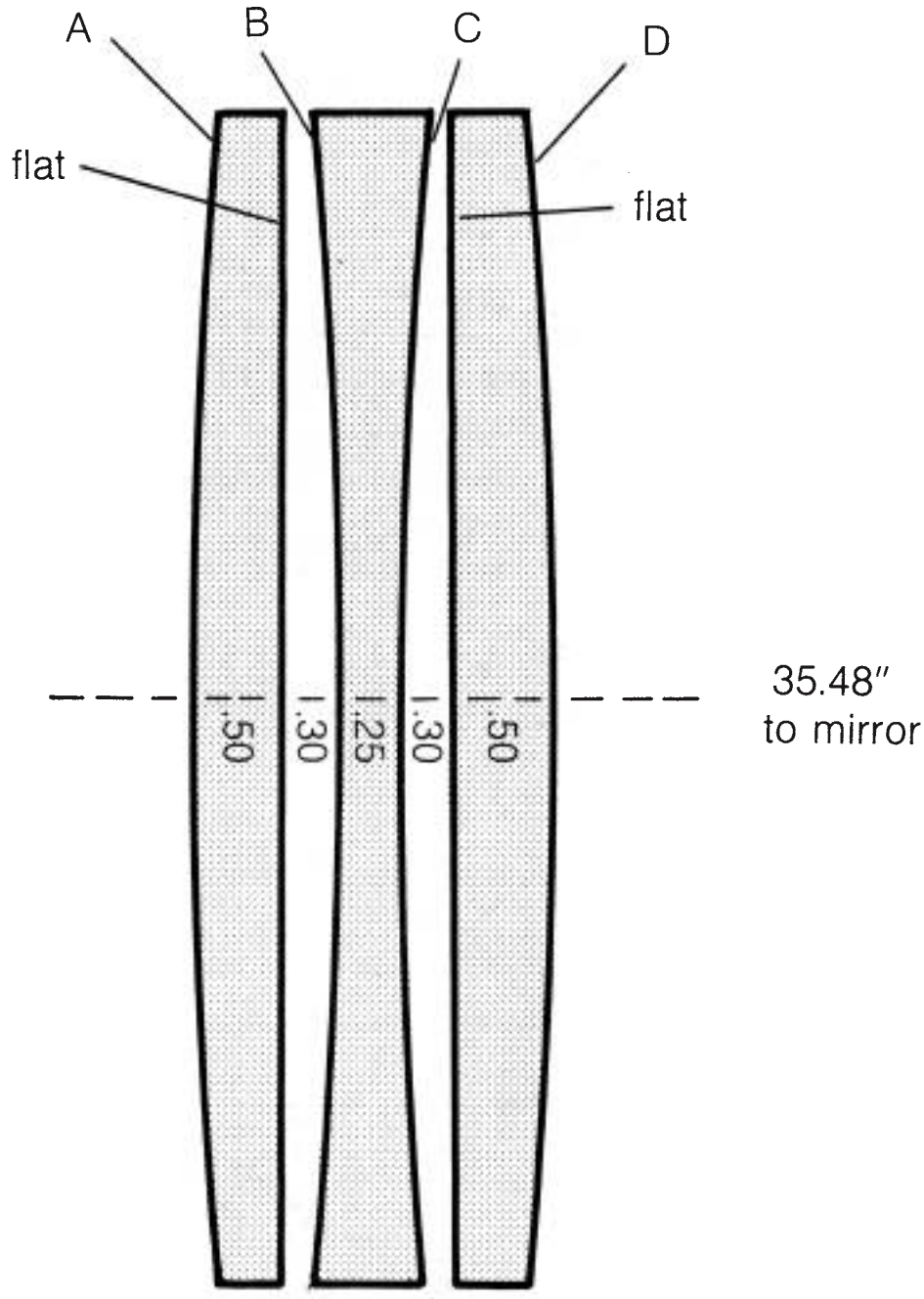
Tolerances

The mirror must be made to within half an inch of the 36″ specified. If it's worse than that, then scale the corrector curvatures in the same ratio. If the mirror comes out long, make the corrector radii long by the same percentage; do the opposite if it comes out short.

One always wonders how well something has to be made to work adequately. You can estimate the unit's performance, assuming the curves are smooth, from the error estimation graph in this article. If the corrector is weak, the spherical aberration will be undercorrected and the blur size large. If the corrector is too strong, the spherical aberration will be overcorrected and again the blur size too large. The rate at which the blur size increases is indicated on the graph.

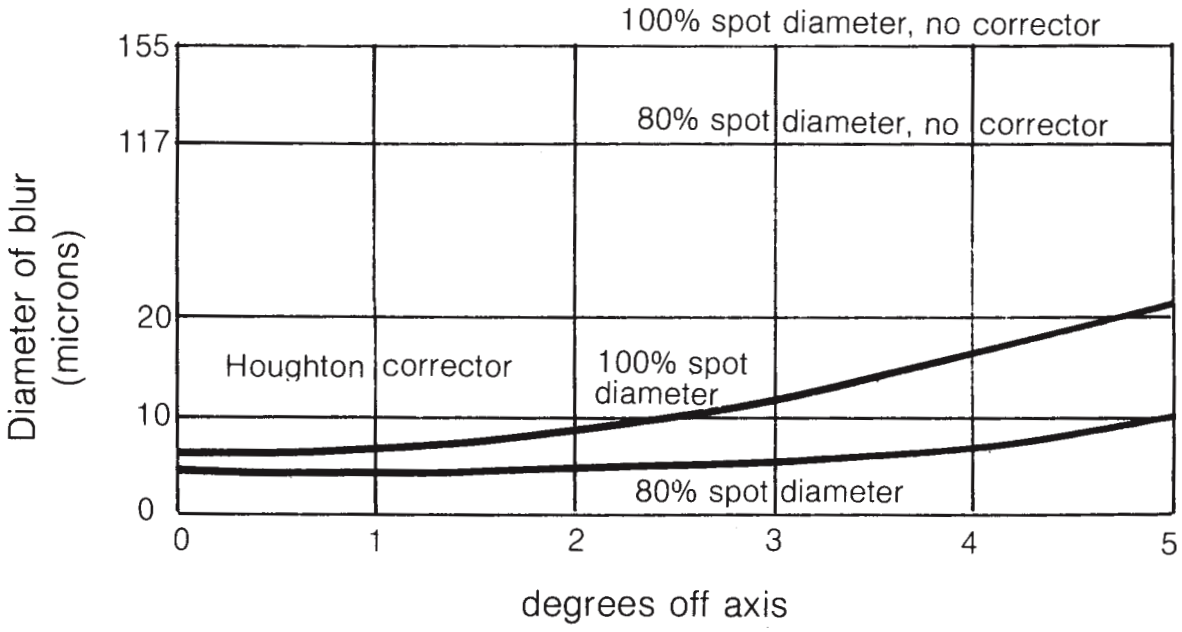
In general, if you have errors at all, it's better to err on the weak side on the

the houghton corrector

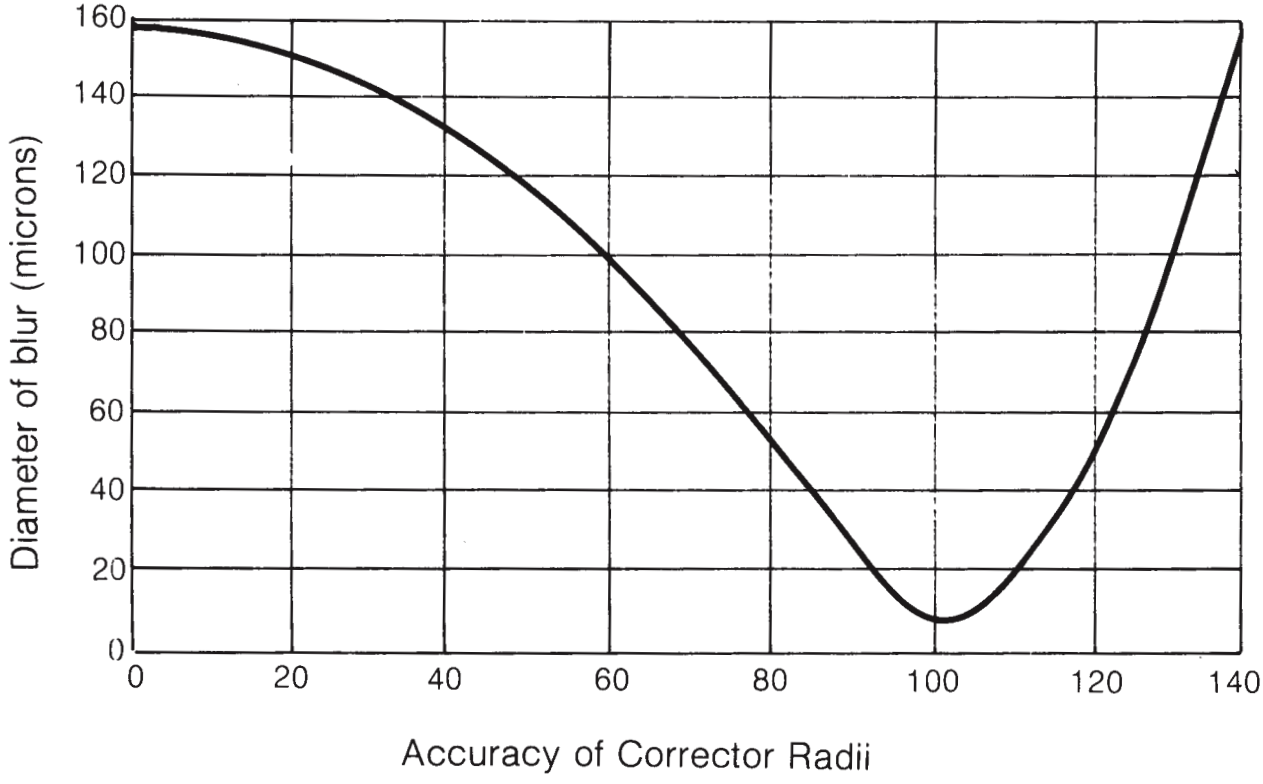


All radii are 34.312″

Grind A against C and B against D



Effects of Error in the Corrector



corrector. The reason is the axial spherical aberration compensates the oblique spherical aberration. The edge of the field is therefore improved compared to the nominal design. The amount required is only a percent or so, and it's probably best to disregard it.

The lenses should be well centered, if possible, although taping the lenses together, which could be considered intolerably sloppy, does work. If the mirror is tiltable, and the film-holder too, then there should be no need to tilt or adjust the corrector lenses, so long as they were reasonably set in line in the first place.

The thicknesses of the lenses are not very important, but it is better to go on the thin side rather than on the thick. Plate glass, if you can find any without serious striation, should do quite nicely. It has a slightly higher index than BK7 (which is desirable), and its dispersion is low enough that it should work well. Opthalmic crown, if you can get it, is good and is of higher purity than plate glass.

Turned edges may be disregarded so long as they are not too severe. On the concave lens, this will cause some zonal undercorrection which can then be balanced by respacing the elements. On the corrector lenses, it is desirable to use black paper aperture stops to prevent glistening edges from fogging the image. My concave lens is ground flat over the last ⅛" and this makes a nice contacting surface.

I never tested any of the optical surfaces for figure. We took it for granted that, being rather strong, they would tend to be smooth and spherical. This seems to have been the case, judging from test photos. TMs may find it fun to test-plate the lenses one against the other just to see how the work is going.

Miscellaneous Comments

A few comments on the making of a Houghton "Schmidt" may be of value. First, be sure you have a nice dark sky! These cameras are so fast and efficient that fogging is a real problem. Second, you'll need a sturdy, well-aligned drive, or field rotation due to misalignment will be a problem. Remember, the camera covers 10°. Fine-grain, red-sensitive emulsions may be used to minimize sky fogging.

Finally, making the optics may be only half as much trouble as making the cells, film holder, tube and access system. My delay in assembling the Houghton was attributable not to the difficulty of the optics (finished three years ago prior to operating the camera), but to the mess of making the mechanical devices.

Is a field flattening lens desirable? Could one be used to avoid the curved image surface? The answers are "no" and "yes." If you must build one, it need be only a simple plano-convex lens. Its radius will be:

$$R = \frac{(n - 1)}{n} \times 18''$$

For BK7 or BSC-2, it comes out to R = 6.13"; for plate glass, to R = 6.17". It should be as thin as possible and as perfectly polished as you can make it. Assuming your nominal Houghton is made as perfectly as you can, you'll find your image quality with a corrector will improve a bit if you increase the air gap in the corrector (do it evenly in both gaps), to compensate the spherical aberration introduced by the field flattener.

However, I would advise against the use of a field flattener. It adds extra losses, and the slightest defects on the lens will record on the emulsion as shadows and imperfections. There is also the possibility of ghost images unless you oil the emulsion onto the flat side of the lens — even then you may get them.

A Prototype Houghton

I started building my Houghton camera back in 1967 with the help of Mr. Al Bowen. We finished the optics in late 1968, but it was not until much later that I got around to making a tube and lens cells. The instrument was first tested on January 1, 1972. The results were good enough to convince me that the Houghton Camera is simple to build, forgiving of errors, and might be of interest to fellow TMs who, like me, feel that a true Schmidt, with its troublesome corrector, would be too difficult to make.

First test photos were taken with the camera unguided and pointed to the celestial pole. Flat KK20 glass plates were held onto my incomplete filmholder using double-sided tape. The camera was adjusted for centering by viewing in and looking at the reflections, and focused on a mountain. At night, a 15-second exposure (the Moon was full that night and my neighborhood is "blessed" with abundant mercury lighting) gave a "sky-limited" exposure. Measuring the plates the following day, the sharply focused areas where the curved image surface intersected the flat plates showed spot sizes under 50 microns in diameter. Because the corrector radii turned out to be 7% too weak, and we didn't bother to rework them, this is not far from the computed spot size of 25 microns.

No indications of ghost images were detected although my lenses are all uncoated, so they must be so far out of focus as to be negligible. Coating will increase transmission by about 30%, but since the camera is f/3, it's got light to spare. It's your decision whether you can afford the luxury of magesium fluoride coatings.

R.A. Buchroeder
7270 E. 19th Street
Tucson, AZ 85710

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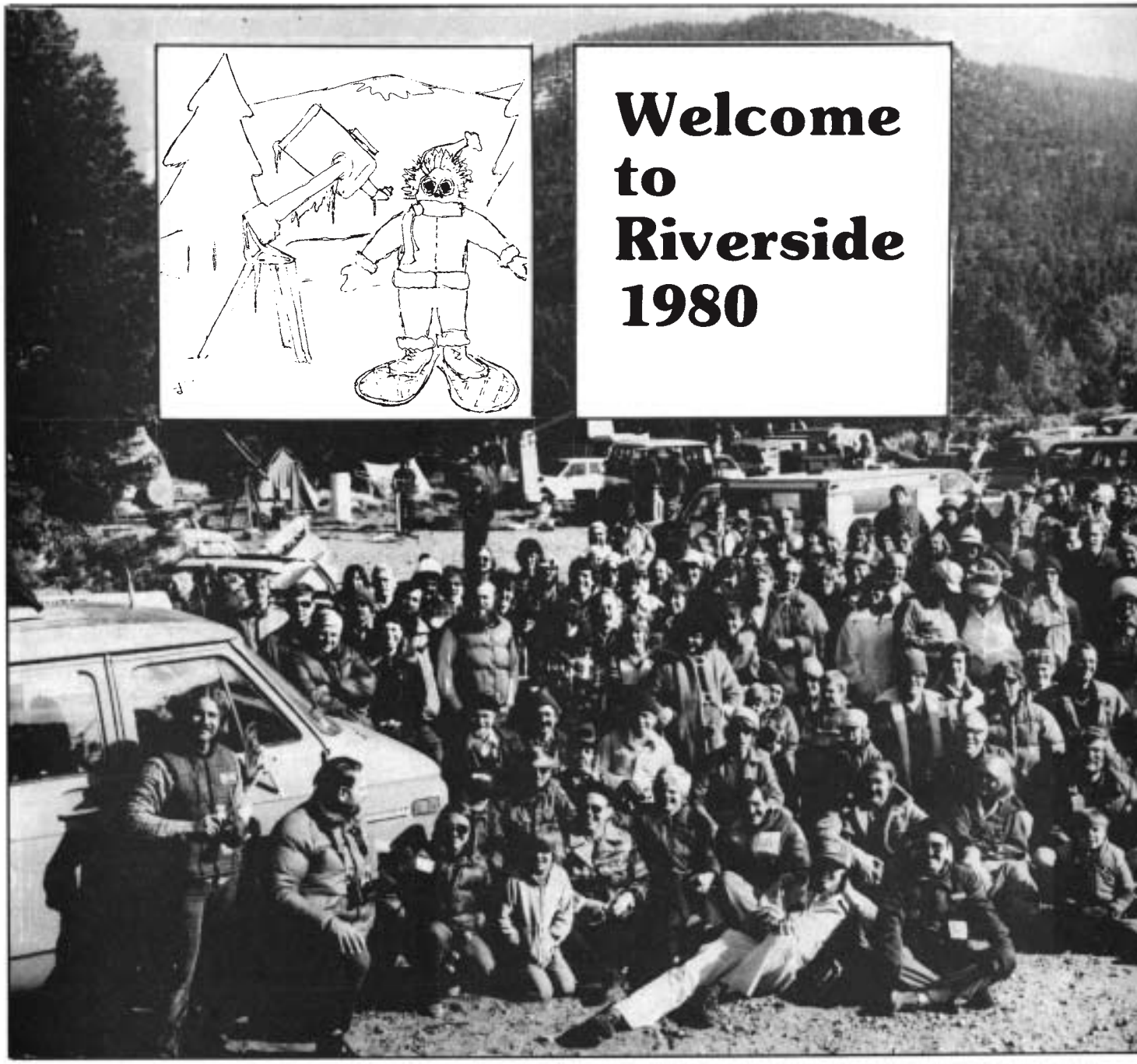


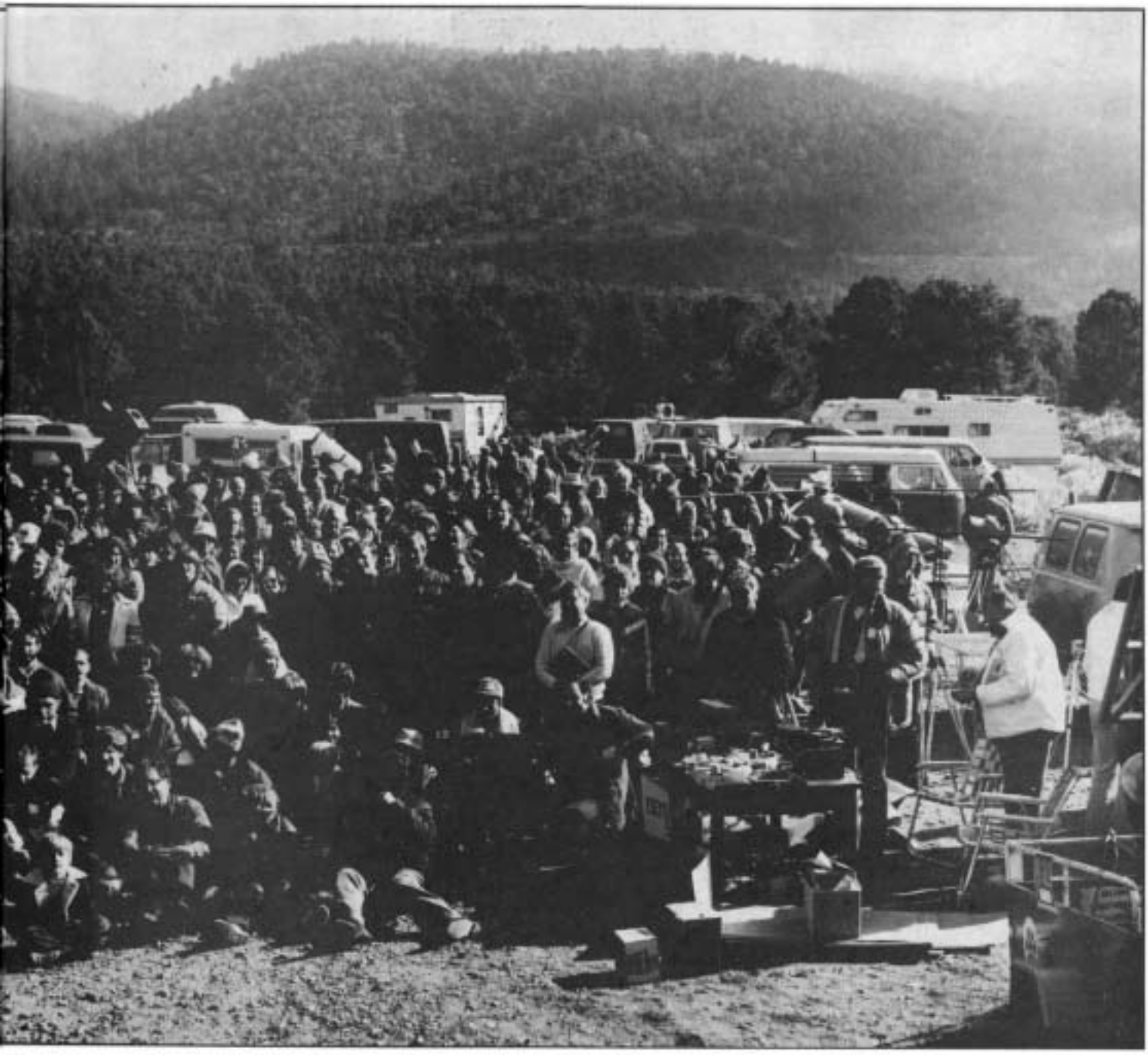
Welcome to Riverside 1980

I particularly looked forward to Riverside this year because, in addition to astronomical activities, Southern California promised warm sunshine, the chance to renew many acquaintances, plus I planned to spend another ten days on the West Coast, to end up in San Francisco for the flight back to Milwaukee. Bob Cox was also flying out to Riverside — which was good because we needed some time to talk about TM and what we're going to be doing in the next year. Another plus — my wife Eleanor had finished teaching for the semester and was free to come along, too.

We arrived at noon on Thursday at Ontario Airport after an almost perfectly clear flight across most of the United States. Only California was clouded in. We had left Milwaukee in the morning of a sunny day with a temperature of 80° -- and the pilot said it was 65° and overcast at Ontario. ("Oh well, think nothing of it — it'll soon get warm and sunny!") So we picked up our rented car and drove to Redlands, ate lunch at a Mexican restaurant, and took a nap. We had arranged to meet Myra and Casper Weir at the University of Redlands to see "their" planetarium. It is nearly unused by the University, so they are fixing it up, updating it, and modifying it so that public shows can be given. (They just might appreciate some help.) We had dinner with them; then the weather broke down — and it was cold and rainy in sunny Southern California.

On Friday, we drove up Hwy. 38 from Redlands, then on up the grades, turns, and twists of the road behind a truck full of horses, finally arriving at Camp Oakes around 11:30. We spent an hour or so talking to the early arrivals, mostly commercial displays from Celestron, Teledrive, R.E. Brandt, L. Henzl, Astroworks, and Roger Tuthill. Then, since it was cold, we drove down to Big Bear to get gloves, mittens, and a warm hat for Ele. We returned, registered, lodged in "Combs" with all the lifeguards, and once again toured the hill. At 3:00 people were arriving steadily, but a strong cold wind came up, blowing dust around, tumbling chairs, and chilling people.

We sought warmth in Ben Mayer's RV, and spent the afternoon drinking warming beverages. Dennis di Cicco, of *S&T*, was there, too, so we invited him and Ben to dinner in Big Bear. Ben accepted, conditional on his paying for the drinks. Dennis seemed to be flabbergasted, but he just couldn't turn down the opportunity to have dinner on



ASTRONOMY's tab. Ben and I wanted to return to Chef Rudi's German restaurant (Rudi is from Milwaukee originally), so, an hour later, off we went. The weather got colder. Big Bear was reported to be the "coldest spot in the nation last night" on the news, at 20° F.

When Saturday morning dawned, there was snow on the ground as I headed for the main telescope area. Most of the instruments and displays were wrapped in plastic or tarpaulins, but the Sun was breaking through pretty often, so we could hope, at least, for fine weather. But it was cold, so after looking at every telescope there was to be looked at, I went down to the meeting hall for warmth. While nursing a cup of hot chocolate, I looked up to see Jay Freeman grinning. He gave me the cartoon, "Welcome to Riverside," that opens this article. The original is drawn on a paper napkin with a felt pen.

The talks began at noon Saturday. I only stayed for the first, David Levy's talk about observing and telescopes for children, because I had to make photographs for TM as well as field measurements on the friction in Dobsonian telescopes for my paper to be given late Sunday afternoon.

On the parade ground, walking from telescope to telescope, I met Dennis Matlock and Jason White, of the Western Observatorium, with the J. W. Simpson Springfield telescope. Mr. Simpson built the telescope in 1949 and set it up in San Jose. It sat atop an 8-foot pier for some years until he moved to Texas, where the telescope was moved but never reassembled. Eventually the telescope was donated, without its 12-inch mirror, to the Observatorium.

Dennis Donnelly was setting up his yellow 8-inch f/8 Dobsonian when I chanced by and measured the force needed to move it. I noticed the "circles" on the instrument and asked. Yes indeed, this was the telescope that Bob Kestner had been talking about when he spoke of setting circles on a Dobsonian telescope. Dennis used a plastic coated tape measure refill wrapped around a wood disk, and running on teflon pads, for his side bearings. The tape provided an accurate divided circle, with 1/16″ equaling ½°. He planned to calibrate the instrument on three stars that night, and search out daytime stars and planets on Sunday. An intriguing thought.

Set up prominently on the parade ground was Dennis Gallagher's coronagraph. The instrument is a 5-inch refractor carrying a

George Montier's 8" reflector

Gary Lopatinski and his 12" Cassegrain

Mark Jacobs and his 16" f/4 Newtonian

solar-disk-rejecting optical train. Prior to the meeting, Dennis had not taken the coronagraph to "corona" quality skies, so he had not yet tried to see the corona. However, this instrument gave me the very best, most contrasty, views I've ever had of solar prominences, far exceeding anything I've seen in narrow-band filter systems. TM will be carrying an article on this telescope in a future issue.

I couldn't pass up the big white Dobsonian at the upper end of the field. It belonged to Bob Ferguson of the Sonoma County group. He spent three years figuring the mirror, but not continuously. He would silver the mirror, and then observe. When the coating began to get poor, he'd strip it and improve the mirror's figure a little more. "It was John Dobson that told me I could make a telescope; I thought it would be too complicated," he said. "For a person who wants to get out and get looking quickly, it's the best way."

That evening, after a long wait in the cold and a dinner of rubber spaghetti, came door prizes. What a hubbub! ("And the winning number is 218-072"...mumble, mumble..."I've got it!" "We've got a winner" for Questar chairs, observing flashlights, and a Meade 100.) Then the LAAS slide show began, and the crowd settled down for an evening of entertainment and talk that was largely starless.

I returned to Dennis Donnelly's telescope early Sunday morning. "Did you see the stars for calibration?" I asked. "Oh, yes, we were just now looking at Capella." I looked, and there it was. "We'll try Venus," he said, and began punching the R.A. and Dec. coordinates and the time into his calculator. It thought for 29 seconds, then displayed some numbers. We dialed them in, looked, and there was Venus. We tried to find Mercury the same way, but without luck. He thought the telescope had a little too much hysteresis in the optics, because we went back and found Venus and Capella again without difficulty.

Later in the day I saw him again. He told me that he and Kestner had worked out the problem and had gone on to find Mercury, Jupiter, Saturn, Mars, Betelgeuse, Rigel, Aldebaran, and several other bright magnitude stars in the daytime sky. All this with an alt-azimuth telescope! I was impressed. For finding lots of objects very quickly with a Dobsonian, this might be the way to go.

The swap meet was the peak of the day for many TMs. On dozens of tables outside the meeting hall lay great piles of stuff — used stuff, new stuff, optics, books, complete telescopes. Several commercial firms joined in selling off quantities of seconds and miscellaneous japanese eyepieces at lower-than-normal prices. I picked up a few small items for myself and steered some friends into buying their first 6-inch mirror for $20 (but they missed a 10-inch mirror going for $60 which I thought was a better deal). I also got an M-17 elbow telescope for my own 20-inch telescope for $25. The price was right.

Gerard Logan's 10-inch clear aperture f/2.3 Schmidt camera, down by the lake, was a beautiful instrument. He has just recently finished it, but I hope that we'll see beautiful pictures taken with it quite soon. It uses a Boston rollerless chain drive on R.A. and a tangent arm in declination. The mounting won a merit award several years ago at RTMC. The tube itself is humble Sonotube, but it's covered in soft brown leatherette which looks and feels very good.

Jack Newton, whom I knew from my years in Toronto, had built and was displaying a very impressive plastic cold camera. I was quite impressed with the camera and the pictures he's taking. Jack is doing a write-up for TM on it.

Another fine instrument was Ralph Parlette's 8-inch Dall-Kirkham Cassegrain. On its high pier (which contains NiCads and an inverter for the drive), this handsomely finished (all the joints are Bondoed) telescope, with homemade 9-inch brass gear and matching steel worm, has "not a bolt or screw on it. It's all tappet knobs."

Two of the nicer telescopes I saw that day were truly unpretentious wooden instruments. One belonged to Ed Ehrhart, a 6-inch f/8 Newtonian, with its homemade peepsight finder and quotations glued to the tube. "It's just the same old square tube telescope doing variable star work for the AAVSO since 1975," he said. The other was an 8-inch Dobsonian built of junk and scrap parts by Dick and Mark Houskeeper (father and young son). It was certainly no work of art, and it was far too lightly built for stability (it had narrow ⅜" sheathing material sideboards, for example), but I felt that here were two telescopes that would be both used and appreciated.

At the awards ceremony that evening, Bob Cox was given the Clifford W. Holmes Award for his contribution to amateur telescope making. The plaque says on it:

"We, your friends, fellow telescope enthusiasts, and amateur astronomers wish to both recognize and express our warmest and sincerest appreciation for your outstanding contributions to the advancement of telescope making. You are one among many, yet as Orion so conspicuously stalks the Winter sky, your talents and your willingness to share with us shine brightly in our minds. We are very thankful."

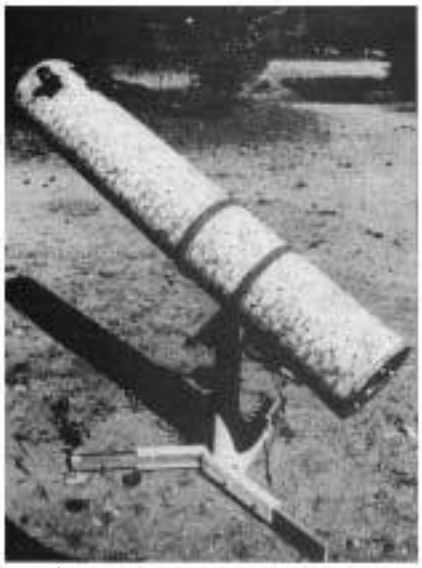
Bob was obviously pleased. He said to us: "...this award is for you. I am you, you are me, and I want the chance to help you..."

George Carrol, one of the founders of Stony Ridge Observatory, was presented with the original driving clock he built for the 30-inch telescope. The drive, built before any electrical power was available on the mountain, ran off 28 volt batteries. "I am proud of that thing," he said, as its shining brass weights swung round and round, "but it wasn't easy. We had no electricity and so we had to do it all mechanical."

Cliff Holmes, practically jumping up and down with joy, said, "You just can't ask for nicer people than astronomers."

Then came the hush, the anticipation of more door prize drawings, groans when there were no winning numbers, and finally the ecstatic yell when someone saw that his number matched, and he was winning a flashlight or a C-5.

Sunday evening finally provided the clear weather the observers were waiting for. As darkness fell, I slipped away from the people who would have talked the night away with me to see the sky. There were already fewer telescopes than there had been the night before. Many people, taking their telescopes with them, had left, unwilling to gamble on



A 6" with the constellations on its tube

Ralph Parlette and his 8" D-K Cass

Herman Meyerdiecks' image intensified RFT

another cold night.

Joining friends, I examined M-13 through Herman Meyerdiecks' 5-inch refractor equipped with a 1-stage image tube. The image was sharp and clear, and looking through the eyepiece, not remarkably bright. But pulling back from the eyepiece, you could see that the exit pupil was about 20 times more luminous than the night sky. That can't happen with a purely optical system because the product of the area and the solid angle of a light beam is conserved. We moseyed along, took photos of the telescope field at night,and oohed and aahed at the images of Jupiter, Saturn, and Mars presented in some commercial Maksutovs of 6 and 7-inch aperture.

It was getting colder, and the light of the near-full Moon precluded serious deep-sky observing, so we said good-bye and the others headed for home. I went over to Bob Ferguson's big white 16-inch Dobsonian and located a number of deep-sky objects — M-13 among them — to assure myself this instrument was as sweet and easy at night as it seemed during the day. It was.

Walking back toward the meeting hall for coffee, I found Ben Mayer and asked to try his Noctron IV. This is a 3-stage image intensifier with built-in battery power supply. Ben was very concerned — one look at a too bright light source could damage the device. I promised to be careful and looked. It was a strange experience. The outdoor world was transformed to a bright-as-day green image glowing on the output phosphor of the image tube. I could see,in the dark, the grass and stones under Ben's RV, and into the shadows under the trees.

Equipped with an 85mm f/1.8 lens, the device gives a 2 or 3 times magnified view. The lens, at least under moonlight illumination, had to be stopped down to f/2.8 or f/4 to keep the phosphor from overloading on the sky. Stopped down to f/16, the image took on a granular and scintillating quality, somewhat like the snow on a TV screen. The eye of a person looking through this "starlight scope" was bathed in a soft greenish glow.

I suggested to Ben we try his new toy out on one of the telescopes. There weren't any operational C-14s, and the people showing off the Questar 12 were closing up shop, so we took the scope up to the big white 16-inch Dobsonian. We removed the Noctron's 85 mm lens and replaced it with a 2-inch eyepiece adaptor, then inserted the whole unwieldy device into the eyepiece tube.

The telescope had been aimed at M-57. I looked in: there, glowing in the characteristic green of the phosphor, sat M-57. You could see the central star. "We're on it," I said. Ben seemed disappointed I hadn't yelled out. The image was a bit grainy, but the Ring stood out clearly and crisply from the sky background, a little oval with deformed ends. I stepped aside, a line formed, and everybody hanging around the scope had a look.

I proposed we try M-13 next. Here the performance of the image tube was truly stunning. Since I had seen M-13 earlier in the same telescope, I was particularly impressed — the globular cluster was a fantastic glowing ball of stars. The screen showed stars considerably fainter than I had seen earlier. The grainy appearance seemed far less apparent with star images than nebular images, and the view was quite satisfying.

I also wanted to see how the intensifier did on galaxian images, so we next aimed the 16-inch at M-81 and M-82. M-82 (the weird one) was well defined, but little more seemed to be visible with the image tube. Visually, M-81 was a soft glow, and with the image tube it was a soft glow with about twice the extent. Contrast in the spiral arms was somewhat improved. The image tube seemed to be limited primarily by the brightness of the moonlit night sky. I would very much like to have seen these galaxies on a night with a dark sky through this amazing device.

Certainly the image intensifier has important advantages to offer some types of visual observing, especially, I suspect, observations of stars and starlike objects. However, we were not equipped to exploit all its advantages, since, for example, we could not change magnification, which might have help with the galaxies and the Ring Nebula. Magnification can only be changed by changing the effective focal length of the telescope, since the intensifier is a fixed focal length device. We also took pot-luck with the f/ratio of the telescope we used. With long ratios, the image would probably scintillate more; with short focal ratios, less.

I was surprised, in talking to a number of observers later, to find they seemed to disapprove of the device. "I want to really see something when I look at it," was one man's response. The tube does de-romanticize the view through the telescope somewhat, but it goes a magnitude or two deeper than you can see by eye — which is equivalent, roughly, to doubling the telescope's aperture.

On Monday, Bob Cox, Ele, and I were invited to tour the Goldstone Facility of the Deep Space Network — the big 34 and giant 64-meter antennas used to track U.S. space probes such as the Pioneer, Viking, Mariner, Voyager — courtesy of Rick Shaffer and the JPL Public Information Office. We left Camp Oakes at about 10:00 a.m. and followed Route 18 down the precipitous north side of the San Bernardinos and into the Lucerne Valley, across the ridges of hills with their valleys between, and into Barstow. After lunch, we all got into Rick's van and he drove us out into the Mohave Desert — speckled with desert flora, often in bloom if examined closely, and a multitude of hills, vivid reds and oranges, the black of volcanic rock, the deeply weathered boulder piles — past the tank crossings of Fort Irwin, along the famous "ten-mile stretch" where you can see the next 10 miles on absolutely straight road, then turned left on NASA Road.

After getting our official visitor's badges, we drove on to the 34-meter dish. It was pointed near the eastern horizon — Rick said they'd probably just acquired a spacecraft — and the orange rotating beacons meant they were preparing to transmit. The microwave power spilled during transmission can be hazardous to your health, so the antenna is cordoned off by a chain link fence that's safe to be outside. About a minute after we arrived, a red beacon came on — the transmission had begun — and some 10,000 watts of power was on its way to a distant spacecraft. Rick pointed out the optics of the dish — it's a cassegrain system with a dichroic beam-splitter near the focus. It can transmit and receive simultaneously at different wavelengths, saving valuable data-transmission time.

We walked around the antenna, picked up a

unique instruments

Bob Minor's 10-inch f/6 bowling ball telescope was by far the most intriguing new idea at Riverside this year. Bob employed a standard 16-pound used bowling ball for his unique universal motion bearing. The ball rides on an old aerial lens cone, chamfered slightly along the inside edge. The ball is waxed with candle wax for the right friction. The open tube and brace are wood. The pipes are attached with ½" NC bolts, the ball being drilled and tapped. The telescope moves like an Astroscan, in no preferential directions, with about 1 pound push or pull.

Dennis Gallagher's coronagraph gave magnificent high contrast views of solar prominences. A 5-inch refractor (the thick part of the tube) provides a solar image blocked by a shiny metal disk at the front of the coronagraph unit (the thin part of the tube held by Dennis). The objective is imaged to a glare stop, the light is filtered, and the sky re-imaged for eyepiece or film.

Delores Hill sits at the eyepiece of the 10-inch J.W. Simpson Springfield reflector of the Western Observatorium. The instrument features a stationary eyepiece position. This telescope will be installed at the Mt. Baldy School on the western boundary of Mt. Baldy Village (4500 feet) near Los Angeles, where it will sit well off the ground.

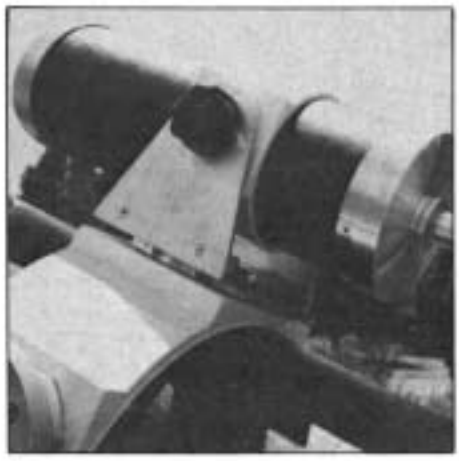
technical prowess

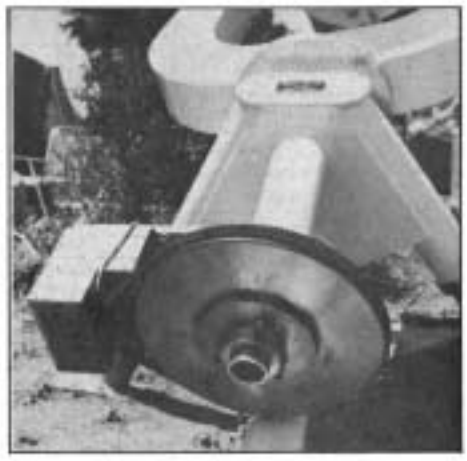
Bob Webb's handsome black-and-tan largely homebuilt 10-inch f/4.8 Newtonian runs 12 volts throughout so he can work at remote sites. Note the neatly-designed declination slow-motion system with 12 volt 1 rpm motor and clutch arrangement for both manual and electric correction. The azimuth adjustment relies on $2 roller skate bearings for fine but easy motion. The 4½" f/15 Cassegrain guidescope is mounted on a camera tripod head; fine adjustment is by means of turnbuckles that bend the mount.

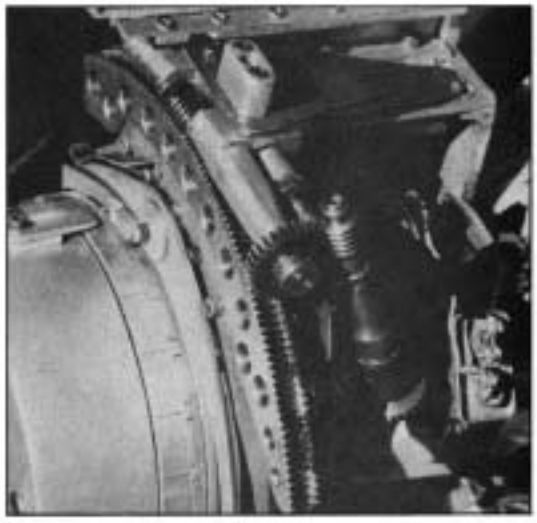
An alt-azimuth with setting circles? You bet! Dennis Donnelly has done it. His bright yellow 8-inch f/8 Dobsonian Newtonian uses plastic-coated tape measure refills wrapped around wooden disks as both circles and bearings for the telescope. 1/16″ = ½° on the circumference, and we'll leave it "as an exercise for the reader" to tell us the diameter of his side bearings. The photograph of Venus was made about 11 a.m. Sunday morning by placing the lens of my twin-lens reflex up to the eyepiece of the telescope. Top, right: Bill Anderson beside his 12-inch Schmidt Cassegrain. He made the corrector via the vacuum method. The primary is f/1.9, the system f/7.5; it's for photography. Middle and bottom, right: Wayne Kaas brought this fork-mounted 10-inch f/8 Ritchey Chretien. Note the shaped light baffle and sturdy mounting.

for astrophotography

Gerard J. Logan's beautiful 10-inch f/2.3 Schmidt camera ought to be a star performer in coming years. Though mounted in a Sonotube, the instrument should hold focus very well because the film holder and mirror are rigidly attached through temperature compensated metal rods. The mount, which features a chain drive, was a Merit Award winner several years ago. It employs a long tangent arm drive on the declination axis. The tiny telescope is a Polaris finder. Its guidescope, a 5-inch f/24 Maksutov, rides in its own extremely smooth fork atop the main telescope.







Cold cameras are still the best bet for aspiring astrophotographers, and if Orien Ernest and Jack Newton's reputations hold any weight with you, here's the instrumentation behind their work. Mr. Ernest is now using a one-arm fork-mounted 8-inch f/5 Newtonian, built with his inimitable welded, sawn, and hand-filed aluminum construction style. All three cameras are pneumatically controlled, air provided by a tiny battery-operated air pump drawing about 2 amps. His drive uses a sector of a gear, rather than a complete gear. Left: Jack Newton proudly displays his (almost)-all-plastic cold camera that allows him to run uncut rolls of film. He holds the shutter control in his right hand. This camera is one of the solid-block types, and, if the pictures he showed are any indication, it's a good design. Jack will describe this camera in a future issue of TM.

Riverside 1980 Merit Awards

Warren Estes Award
"for the best use of simple materials"
Robert Minor, Berkeley, CA
10" f/6 Bowling Ball Telescope

The Clifford Holmes Award
"to the person who has done the most for amateur telescope making"
to
Robert E. Cox
Given jointly by Richard Poremba and Luther Davisson of Astronomy for America
and
The Riverside Astronomical Society
Plaque plus a check for $100

Junior Award
Greg Burns, San Juan Capistrano, CA
6" f/8 Newtonian on a Homebuilt Mount

Astrophotography Award
Orien Ernest, Hollywood, CA
8" f/5 Newtonian Air-powered Astrophotographic System

Innovative Design for Portability
Wayne A. Kaaz, Costa Mesa, CA
10.25" f/8 Ritchey-Chretien

Excellent Craftsmanship
Maynard Clark, Sedona, AZ
8" f/8 Newtonian

Stability and Craftsmanship
Bob Webb, Woodland Hills, CA
10" f/4.8 Newtonian

Craftsmanship and Application
Jack Newton, Victoria, B.C., Canada
Plastic Cold Camera

Workmanship and Unique Design
James Schwartz, Chico, CA
4" Folded Refractor

Unique Engineering
Andrew Tomer, Atwater, CA
12½" f/15 Trailer-mounted Cassegrain

Innovative Idea
David Levy, Tucson, AZ
4" f/15 Mintaka, the "talking telescope"

Best Wooden Mounting
Thomas Greska, Woodlawn, CA
3" f/10 Newtonian

Excellent Workmanship
Tom Scott, Fresno, CA
12.5" f/3.85-f/25

Excellent Craftsmanship and Construction
Ralph Parlette, Mill Valley, CA
8" f/15 Cassegrain

Honorable Mention: Innovative Design
Steven Wissler, Lawndale, CA
Three Wire Reticle Eyepiece

Honorable Mention
Chris Shuur, Prescott, AZ
Hubcap All-sky Camera

few souvenir bolts and washers, then got back in the van for the drive over to the 210-foot (i.e., 64-meter) dish. Rick said that when we'd just see it, we'd be 1.1 miles away. I kept scanning the hills for telltale white antennas, but there was no missing it when we suddenly came over the last rise, and there, gleaming white in the Sun, was the squatty alt-azimuth mounted antenna.

We parked beside the main building and went in to meet the facility supervisor (you can't just show up — this kind of thing must be arranged well in advance). The main control room is remarkably simple — everything runs from just three consoles. The next room, a room roughly 60 feet long by 30 feet wide, is filled with computers that feed those consoles, that detect and condition the signals, that rotate and elevate the antennas to precise alignment (.001°) with distant spacecraft. On the glowing green face of an oscilloscope tube, we saw the incoming signal just a few decibels above noise — from Pioneer 10 now nearing the interface of the solar and galactic winds. The spacecraft lay only a few degrees from the Sun on the sky, so the shadow of the secondary fell almost centrally on the gleaming white surface of the dish.

We crossed and entered a tiny door in the base of the antenna, looked at a display showing the building of the antenna and at the transformers that handle the incredible 400,000 watts of radio power they can broadcast (the transmitter consumes 1.2 Mw — more than many small cities), then stepped through a door to the rotating stairway, and climbed it to the almucantar room just above the azimuth bearing.

Inside it is terrifically noisy with the roar of pumps pressurizing oil to 2500 p.s.i. for the oil-pad bearings that make the structure possible. Nominally .010 thick, the oil film is closely monitored, for if metal should ever touch metal, it would instantly pressure-weld solid. There are three pads, and four fluid drive motors to drive the pinions that turn the entire structure. Oil, the management of oil, reserve oil, oil pumping, handling, filtering, and the repair of concrete damaged by oil, are clearly a major preoccupation of the staff who work on the antenna.

More than anything else, the antenna feels like a ship. Once you're on it, everything is metal, moving, roaring with bulkheads, passageways, gaugeways, ladders, grillwork platforms. And it's all moving.

We climbed to the level of the elevation gear to examine the hydraulic motors that raise and lower the dish. Here, movement is palpable — the gear track sliding second by second into the pinions that drive it. One tiny gear, about 1" thick by two feet in diameter, a precision-machined part of a giant meccano set, a pinion with 8 teeth, is the position pick-off. We climbed higher yet — to the level of the altitude bearings. At their intersection, in a little room we cannot enter because the big dish blocks our accessway, a master equatorial mounting receives a beam of artificial starlight from a collimator mounted on the dish. Error signals from this gadget keep the dish aligned. Rick says that a Riverside participant of last year (Jeff Schroeder, who built the 11-inch refractor) is now rebuilding the unit.

We couldn't climb any higher with the dish tracking and tipped over on a 45° angle. But I was satisfied — and I'd rather Goldstone's 210 feet listen to Pioneer 10's signals than listen to my wowing about its size.

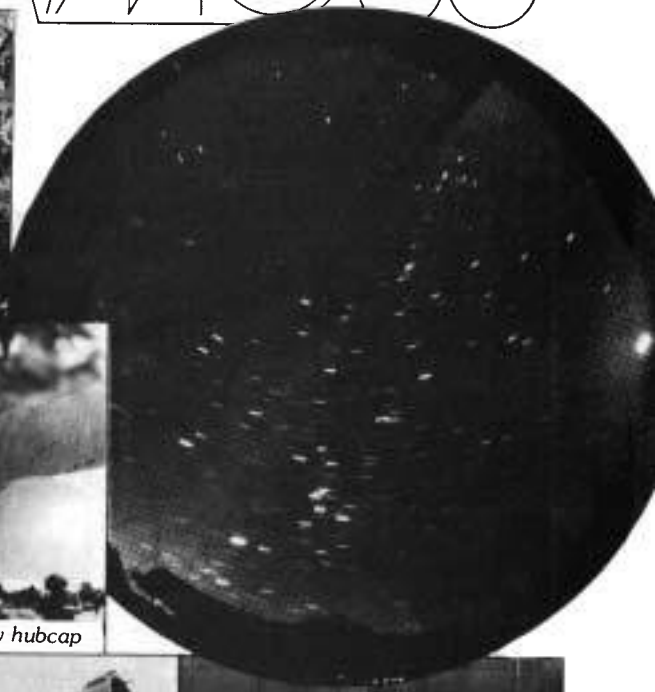
On the underside of the dish, I noticed an irregular mass of sticks hiding under a beam: "You've got some inhabitants up there."

"Yup," says our guide, "two ravens. We call 'em Homer and Jethro."

We drove back toward Barstow with the rays of the Sun lengthening. Rick offered to

Eleanor Berry and Tom Mathis' 6" Newt-Mak

Bob Cox and Art Leonard



Chris Schur and his all-sky hubcap

James W. Schwartz

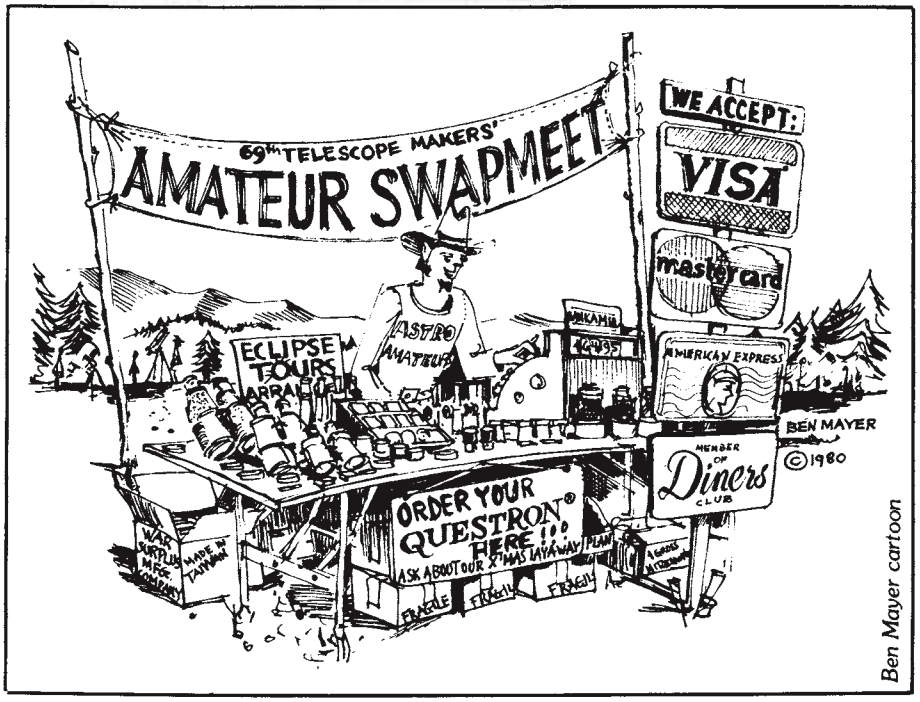
The TM display

David Shipman looks through his 12"

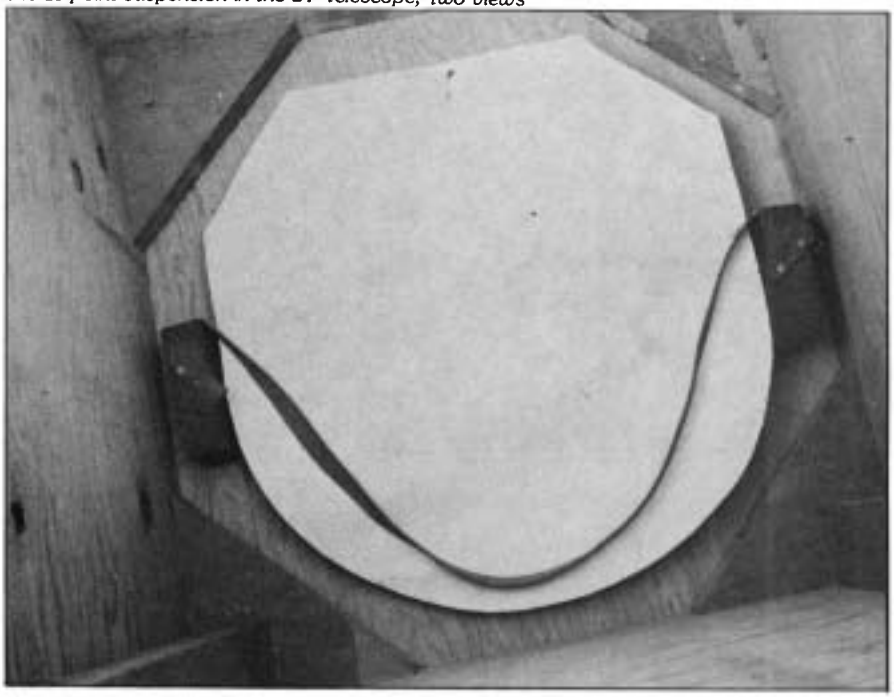
take us to meet "Cold Beer Bob," a noteable AAVSO member whose very homebuilt 16-inch reflector produces a steady stream of observations, and whose occupation is selling cold beer by the roadside. We must decline, but promise to return to see Cold Beer Bob another time.

In Barstow, after dinner together, we headed off in our various ways — Bob Cox to visit his brother, Rick to home, and Ele and I to drive back through Big Bear to Forest Falls to stay with friends. Crossing the desert, driving into the mountains, under the near-full Moon, is a beautiful, dreamlike journey. Past Onyx Peak, though, the road was engulfed in dense fog, and after ten miles of driving cliffsides in the fog, I decided discretion was the better part of valor, so we pulled off and slept in the car. Through the fog, we could hear a mountain stream — in the morning we saw a slender, white stream tumbling down its valley.

We drove down the rest of the mountain (as driving is easier in the daylight), had breakfast, and struck out for Indio on 10, then down 86, through palm groves, past the dry resort towns on the Salton Sea, and into the Anzo Borega Desert on 78. Many species were still in bloom, including the red spiked ocotillo and



Ben Mayer cartoon



the 18 point suspension in the 24" telescope, two views

Brian Rhodes and the 24" mirror

Moving the 18" telescope

the yellow stalked agave. The highway then rose into the mountains to Julien, where we headed south on 79, and through a beautiful land reminiscent of New England. From morning in the mountains, across the desert, into more mountains, to the tropical seacoast — we had never seen so much climatic variation, so many vegetations, such lushness and raw grandeur — California at its best.

We followed 8 back to sea level, and into San Diego, where we stayed with John and Stephanie Mood in their apartment just a half a block from the ocean. The next day they showed us around San Diego; we drove the Coronado Bay Bridge, went to the National Monument, and saw a seal eating a bright orange garibaldi and another sunning himself on the rocks.

For a year, John had been planning to see a rocket launch from Vandenburg A.F.B., and it happened that *that* Wednesday was the night. A phone call — and the fact that there was still room on the buses — got us onto the official list. We drove pell-mell for Vandenburg after leaving San Diego at 8:30 p.m., arriving at VAFB at 2:30 p.m. — after a frantic drive over the last 30 miles at 75 mph — just in time to hop on the buses to the viewing area.

The launch was an Atlas rocket, the payload an NOAA weather satellite. Launch time was 3:53 a.m. Minutes fled by; a cloud of vapor from LOX boiloff drifted down from the brilliantly lit rocket, then the countdown 10,9,8,7,6,5,4,3,2,1,0, ignition, liftoff — a brilliant yellow-orange light lit the whole sky. There was no sound. Billows of smoke appeared at the base of the rocket. It rose on yellow-white flame, twice, three times its length. Then the sound reached us — a low rumble growing in intensity, shaking the ground, explaining the brilliant light rising more and more quickly into the sky.

"Liftoff plus 6,7,8,9,10 . . . " as the rocket began to leave us and Earth behind it. "Right on the money, it's on the money, on the money," said the voice on the PA system. Two minutes into the flight, the main engines — now burning deep orange — shut down and the second stage ignited, a white star as bright as Venus. Within minutes, all we could see of the rocket was a 3rd or 4th magnitude star moving slowly among the stars. We said good-bye to John and Steph at the 24-hour food store next to our motel and turned in.

The next day, on the radio, we heard that a malfunction in the rocket prevented its attaining the correct circular orbit, and that NOAA had a $15 million satellite in a useless elliptical orbit.

Ele and I spent the next week sightseeing our way up the Coast Highway toward San Francisco. We stayed with my brother Martin in Mountain View, exploring the beautiful city of San Francisco for several days, and were able to see the San Francisco Sidewalk Astronomers before they left on their annual trip to the Grand Canyon to show the stars to the public.

We arranged to meet John Dobson at Brian Rhodes' house in Pacifica. When we got there, there was no trouble recognizing the place with the old yellow schoolbus and a trailer bearing a huge purple, bright blue, and dark blue rocker for a large Dobsonian telescope out front.

We introduced ourselves to Brian, who was

working very hard on getting hundreds of big details taken care of — details like the license plate attached to the trailer. John Dobson was supposed to arrive shortly with the RV that was to replace the old bus.

I examined the giant rocker, completely rebuilt. Its side panels were cut from heavy used doors. Even the holes for the doorknob and mailslot were still present. It turned on a teflon ring with about an 18-inch diameter riding on three teflon pads. The side bearings were some sort of phenolized cloth ("old silk stockings embedded in plastic"), all salvaged materials. Bits of the old rocker and telescope, now disintegrating from years of weathering, lay around Brian's workshop. Inside the bus was a complete 18-inch telescope as well as the tube for the 24-incher. It is painted blue, with stars and clouds, and measures 30-inches in diameter and 11'9" long.

When John Dobson arrived in the RV, the real activity began. He was pretty frantic, and the RV clearly wasn't going to be as satisfactory a vehicle as the reliable worn-out old bus had been. It lacked pick-up and hill climbing ability, handled poorly, and wasn't anywhere near as adaptable. Still, it had to be readied for a departure the next morning, a goal they clearly wouldn't achieve. And there was a lot of work still necessary on it — such problems as getting both large telescopes to fit. We all ended up pitching in, cutting out seats and modifying the RV, lugging telescopes around, and helping out where help was needed.

As I lugged them around, I got to examine the telescopes pretty carefully. The wooden secondary supports on the 24-inch telescope run in grooved wood slots mounted inside the tubes, and the spider vanes are held with thin wood slivers that bore a curious resemblance to popsickle sticks. On the 18-inch, the ends of the spider legs are simply glued in place.

The sonotube of the 24-inch is stiffened by three ¾" plywood rings about 2½" wide, one near the top and two near the bottom, leaving a clear shot about 25-inches in diameter through the tube. When Brian unloaded the mirror, I had to get a look. It really *is* as thin as advertised (i.e., 1"), has somewhat sleeked surface, needs a new aluminum coating, weighs about 40 pounds, and is 25" across. In use it's stopped down to 23½", a tribute to a mildly rolled edge.

I also climbed up and looked into the big rocker at the 18-point floatation for the mirror. More Dobsonian technology — all wood and cardboard!

The next day, we drove up to Concord to see Bob Kestner. He is writing an article for TM on grinding, polishing, and figuring thin mirrors which ought to become *the* definitive work on the subject when it's done. Bob learned mirror making from John Dobson and has "gone pro" — he now works for Tinsley and handles big mirrors routinely. For those of us who can't wait, I asked him to describe the techniques "for somebody who has worked conventional 1:6 thickness blanks." Here's what he had to say:

"These techniques may not seem like enough to control astigmatism and flexure in a large thin blank, but they are. I just don't want to see somebody get into troubles, or to attempt this kind of work without enough experience. Well anyway, here's what you do.

"Work the mirror face up on thick carpeting, such as shag carpeting or deep pile. In fine grinding down to about #400, I sometimes just work on a clean towel on the shag carpet on the living room floor. With finer grits than #400, though, strict attention to controlling astigmatism is necessary. Oh yes, fluff the carpet after each session; don't let the pile get mashed down.

"Rotate the mirror frequently. Once per trip around the barrel is enough. Make the amount of rotation random, and in the range of 1/5 to 1/3 of a turn.

"Don't touch the mirror at all. Heat from your hands will expand the outside edge; you'll polish the glass off, then when it cools you'll have a rolled-off edge. Wear leather gloves, or something that sticks to glass. I use "Boss" leather gardening gloves.

"You've got to have excellent contact with the lap for polishing. You can tell when you've got it because the drag on the polisher is very great. Use a very slow stroke. It's right when it really starts to pull, usually just before you'd slop on more polishing compound. Don't. You want that drag, so keep right on going. I can't polish (on a 16-inch mirror) for more than half an hour before my shoulders start to ache. I sometimes tip the 55 gallon drum — which is full of water — when I'm polishing. Good contact will give you a very smooth surface."

Bob uses butcher paper (a thin waxed or plasticized paper) between the lap and the work for cold pressing. This prevents sticking and promotes contact.

"Especially with portholes, be ready to mask off the outer ¼". Later, if you want, you can learn techniques for controlling a turned edge, but if you want to work like the professionals do, don't spend a lot of time playing with the edge. Work that's perfect to the edge usually quotes out at twice the cost. The clear aperture (i.e., the diameter over which the work must meet specs) is always smaller than the full diameter of the surface.

"Testing is the tricky part. Learn lots of tests, and use them all." Bob seems to use the star test on the diffraction image (as the SFSA does) for his standard, but also use Ronchi bands on stellar images, the Dall null test, and the Foucault test.

Bob is currently working, by hand, on a number of 16-inch mirrors and a 25½-inch blank that's 1⅝" thick. He plans to use it with a 24" clear aperture, but if it comes out that the whole aperture is useable, so much the better. Bob polishes and figures a 16-inch disk in 4 to 5 working hours, and attributes this relatively short working time to extremely good lap contact and lots of experience. His 25-inch blank, when I saw it, had 6 hours of work on it, and he estimated it was 50% polished. Bob, at least at home, doesn't use machines.

When Bob's article appears, it ought to provide us all with the information, if not the means, to make our own large-aperture thin mirrors.

The next day, Ele and I flew back to Milwaukee, our astronomical trip to California over at last.

— Richard Berry

RMO 80

Goldstone

Vandenburg

Point Lobos

The Poncet Mount

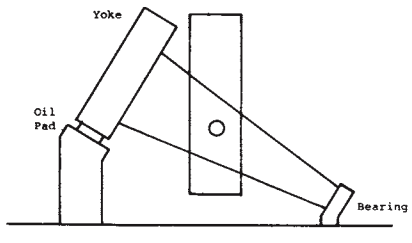
Telescope mountings take two general forms, the alt-azimuth and the equatorial design. Both have two axes; their difference lies in the alignment of those axes.

The alt-azimuth has one axis (the azimuth) parallel to the local force of gravity (and thereby perpendicular to the surface of the Earth) around which the instrument rotates. The second axis lies at right angles to the first, providing motion in altitude. Because they are symmetrical with respect to gravity, it is easy to build these mounts so they are extremely stable.

The equatorial has two axes at right angles to each other, but the principal one is parallel to the Earth's rotational axis. Motion about it allows the telescope to "derotate" the Earth's spin, and thus continue pointing at a celestial object. The second axis allows the telescope to reach any part of the sky. Equatorial mountings, as a general rule, aren't as stable as alt-az mounts because they are asymmetrically loaded.

Obviously, being able to automatically follow a star is advantageous. In the common equatorial, the means of tracking is clear and straightforward. However, there have been mountings for star tracking in which it was not readily apparent to the observer just how the final result is obtained.

The Foucault Siderostat, presented by Foucault in 1869, directed a beam from a celestial object to a stationary horizontal telescope by reflecting the object off a flat mirror. Its biggest fault is that the field of view rotates around the center of the field as it tracks across the sky. In astrophotography, this is overcome by counterrotating the photographic plate in the telescope focal plane.

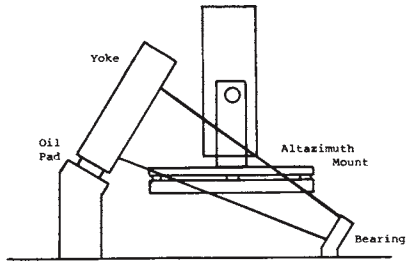


Now 108 years later, Adrien Poncet of St. Claude, France has developed an ingenious mount. It was first presented to the American amateur in the January 1977 *Sky and Telescope*. Like the siderostat, this device at first appearance does not reveal its capability of equatorial tracking. Probably because it is not obvious, it has not had the reception it deserves, and amateurs have thereby lost its capability.

Monsieur Poncet explains that his novel design was developed from a simple mechanical theorem: "A rigid body that contains three points, one acting as a fixed pivot and the other two being constrained to move in a fixed plane, can only rotate around an imaginary axis perpendicular to the plane and passing through the pivot." Using the Poncet principle, it is possible to construct a low table or platform that remains nearly horizontal to the ground, yet allows any instrument put upon it to track in an equatorial manner when the mount is rotated around its pivot point. It is possible to place an alt-azimuth mounted telescope on a Poncet base, point it to an object, and have the telescope track the object across the sky.

To understand graphically how this mount works, consider the basic horseshoe design of the 200-inch telescope with its large yoke turning on oil pads about a polar axis bearing. It should be immediately apparent that this mounting satisfies the theorem of Poncet: the two oil pads in their inclined plane and the large bearing on the south end of the mounting provide the two points and the bearing the pivot.

So what's special about the Poncet idea? To carry the basic idea a little further, let us remove the telescope and

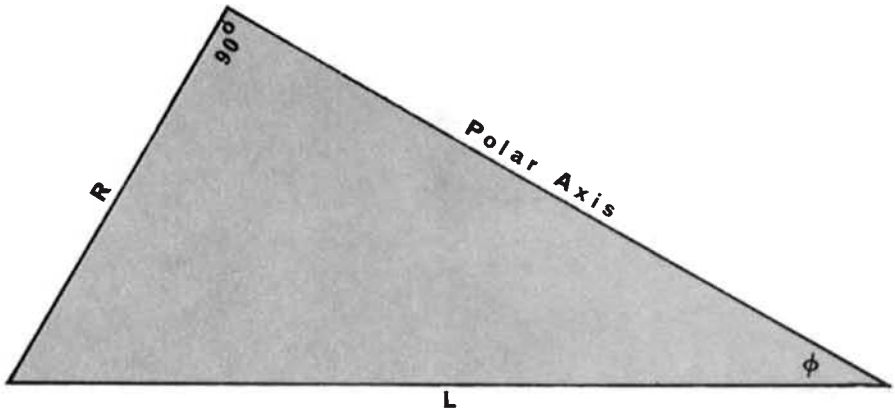


most of the mounting, and substitute, in its place, a platform in the center of the mounting that is parallel to the Earth's surface. Now let's put back the telescope, mounted on a simple alt-azimuth assembly, so it is possible to point the telescope as an alt-azimuth unit. This unlikely structure, using the horse-shoe and south bearing, still tracks like an equatorial. Basically we have achieved the principle of the Poncet mount, although it would be ridiculous to put the time and money into such a structure.

It is the simplification of the situation just described that is the important part of the concept. As M. Poncet explained, his tracker involves an inclined plane and a pivot point that do not necessarily have to be arranged, by appearance, to the basic equatorial mount.

To reach the simple basic Poncet unit, imagine that the inclined north end of the 200-inch telescope mount is extended to the ground to become the inclined plane of the Poncet. Now a horizontal table placed so it has two fixed supports sliding on the outside of the inclined plane with a third point that is the pivot, is put at the south end. We still have a horizontal platform with the tracking capabilities of an equatorial mount.

The one stringent requirement in the construction is that the angle formed by a line extended from the inclined plane intersect a line through the pivot point and the north celestial pole at a right



angle.

In its simplest form, the device does not require a complicated bearing at the south end of the platform. A simple upright shaft in the base plate with a pointed end (to minimize wear, the point should be rounded) plus a conical depression in a matching piece on the bottom of the platform, will provide a good bearing. If the inclined plane is placed at an angle to the base equal to the colatitude (90°–latitude) then the construction requirement of a right angle between the polar axis and the inclined plane is automatically met. One drawback of this particular unit is that it can fall apart because the cup rides freely on the upright shaft. This could be minimized by a heavy spring holding the base and platform together.

A practical solution is to put a conventional polar bearing at the south end, although this makes it necessary to carefully control the angle of the bearing shaft in the construction. The shaft and bearing must make an angle to the base equal to the latitude of the observer in order to intersect the angle of the inclined plane at the required right angle.

Although this complicates the construction, by requiring two controlled angles, it keeps the base and platform from separating in handling. The bearing does not have to be complicated: my first unit used a ¼"-28 threaded bolt in a wooden block attached to the bottom of the platform. It is possible to buy threaded rod up to at least one half inch in local hardware stores, so the hobbyist should have no trouble using this approach.

The simplest arrangement for the inclined plane is to cover the surface of a wooden block with formica and attach it to the base plate. Two teflon pads on blocks on the bottom of the platform make a very smooth, simple, and low-cost slide. Other arrangements can be ball bearings in place of the teflon. These are readily available as skate wheels and ball casters that are put on the bottom of furniture. Formica and teflon, used in combination with the threaded rod described above, leave nothing to be desired for smoothness in tracking.

In keeping with the simplicity of the rest of the design, tracking is accomplished with a tangent arm drive made of threaded rod on which a traveling nut carries the platform east to west. Due to the non-constant tracking rate of a tangent arm drive, it's not perfect, but most units will follow an object reliably for an hour. The platform and driving nut are connected by a hinge-type coupling, the flexibility of the hinge assisting in reducing the twisting action of the arm as it operates.

Calculating the mechanical parts for a simple drive of this sort is pretty simple. Start by assuming you already have a threaded rod in mind. If you know the

$$R = \frac{1440 \times rpm}{2 \times 3.1416 \times TPI}$$

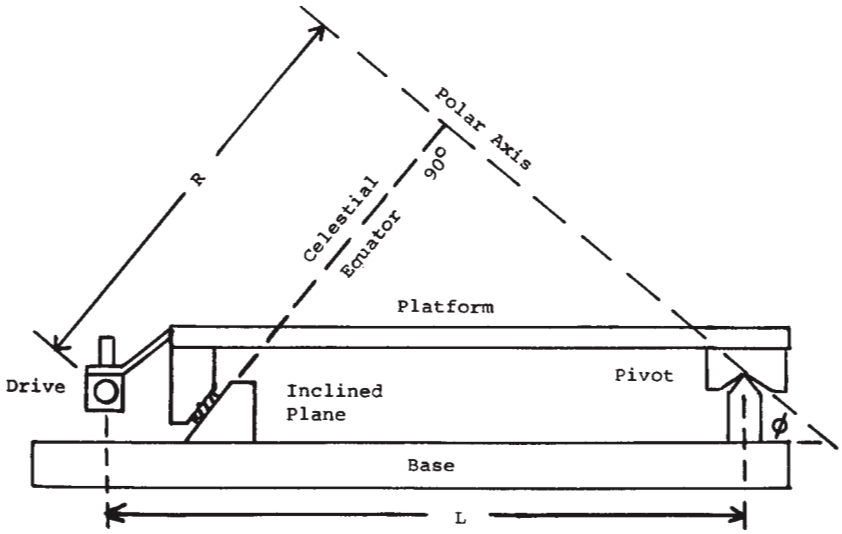
$$L = \frac{R}{\sin \phi}$$

$$L = \frac{1440 \times rpm}{2 \times 3.1416 \times TPI \times \sin \phi}$$

$$A = \frac{2 \times 3.1416 \times R}{24}$$

	1 rpm Motor			½ rpm Motor		
TPI	R	L*	A	R	L*	A
40	5.730	9.177	1.5	2.865	4.589	0.75
32	7.162	11.471	1.88	3.581	5.736	0.94
28	8.185	13.110	2.14	4.093	6.555	1.07
24	9.549	15.295	2.5	4.775	7.648	1.25
20	11.459	18.354	3.0	5.730	9.177	1.5
16	14.324	22.943	3.75	7.162	11.471	1.88
14	16.370	26.220	4.29	8.185	13.110	2.14
12	19.099	30.590	5.0	9.549	15.295	2.5
8	28.648	45.886	7.5	14.324	22.943	3.75

L* is calculated for a latitude of 38° 38'



number of threads per inch on the rod (TPI), it is next necessary to find the radius (R) of the equivalent worm gear in order to locate the position of the rod. For a drive motor turning at rpm revolutions per minute, this is the formula:

R = (1440 x rpm)/(2 x pi x TPI)

where 1440 is the number of minutes in a day, and rpm is the motor speed.

Now the distance from the pivot point to the threaded rod is equal to R/sin(lat), so you can calculate L directly by the following formula:

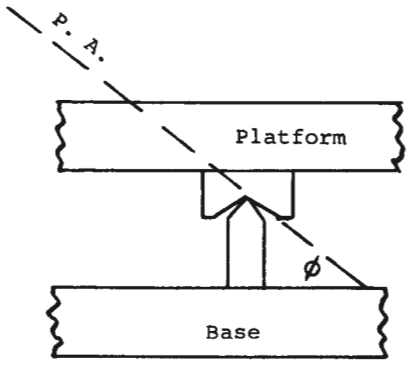
L = (1440 x rpm)/(2 x pi x TPI x sin(lat))

Without the use of a complicated cutout template, it is not easy to use the distance R directly, so it is much easier to figure out the distance L, shown on the diagram.

How long must the tangent arm rod be in order to track for the necessary one hour? It is simply 60 turns of the rod for a 1 rpm motor. For a rod with 24 TPI, and a motor driving the rod at one rpm, in one hour the rod turns 60 times; if we divide 60 by the threads per inch (24), we have the distance traveled around the periphery of the equivalent worm gear, or 2.5 inches.

The table gives parameters of R, L, and A for various standard threaded rods, where A is the equivalent gear distance traveled.

The teeth of the threads become shallow on rods having more than 28 per inch, so if they are used, care must be taken to keep them clean for smooth



operation of the drive. Note that a slower motor, one with ½ rpm is also given, so you can build a mount with a coarse thread, if you want, without L becoming awkwardly long.

Since a tangent arm drive has a limited travel, what can you do to prevent damage to the drive if you forget it too long? Without any limit switches, you can have a safety device built in the threaded rod. If you make the rod slightly longer than needed and then cut away the threads on the last half inch at the end of the travel, the nut will run off the threads and idle while the rod turns easily under it.

This mount seems ideal for the amateur: it's low in cost, easy to construct, it tracks, provides alt-azimuth stability for the telescope, the eyepiece stays relatively fixed in location, no counterweights are needed, and it has the potential of carrying more than one telescope or camera on the platform at the same time. Surely there are some faults that are perhaps not apparent at first examination.

Two objections might be mentioned. For one, it is necessary to reset the traveling nut every hour, and second, the telescope must be reoriented on the celestial object at the same time. Few observers work for as long as an hour on a single object and the convenience of the mount would seem to more than offset these objections.

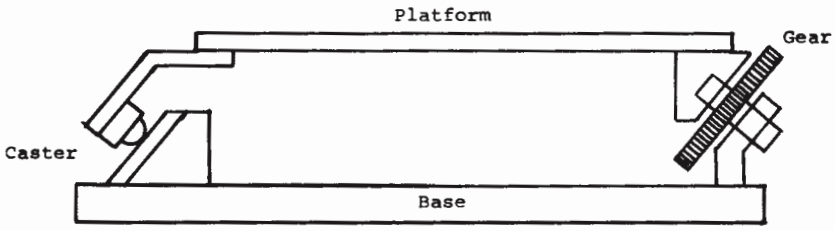
Furthermore, the limited tracking can be overcome by making the design more sophisticated. Make the pivot point a large bearing and shaft upon which are mounted a gear and worm to drive the axis at a tracking rate. Now the inclined plane is replaced by an arc, still inclined to the colatitude and the mount structure cut away to allow a greater swing around the pivot. It should be possible to have tracking of 4 to 6 hours if this is carefully done.

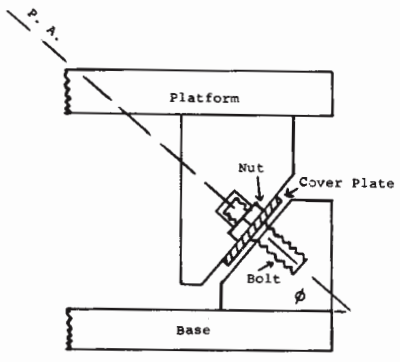
Two things will determine the time of tracking: the height of the platform off

the base before its structure will interfere with the tilt of the platform, and the balance of the unit as it is swung to large hour angles. The first can be overcome by careful layout of the parts, and the second minimized by the use of a counterweight as necessary.

Using the Poncet mount as a camera holder for astrophotography in some situations can present problems. As long as the object being photographed is near the meridian, good pictures can be made, but at large hour angles, if it is necessary to guide in declination, the mount will not track correctly. A study will reveal that near the meridian it is possible to shift the telescope or camera at right angles to the equator (i.e., in elevation) to correct the shifts in the image location. Such errors in most cases can be caused by poor alignment on the celestial pole. Due to the alt-azimuth type of mount, at large hour angles it is no longer possible to achieve a correction at right angles to the equator. As a consequence, guided pictures will have a central object sharp, but objects near the edge of the field will show a rotation around the center object resulting in a tracking error at right angles to a line between the central object and the star image at the edge of the field.

However, there is both good news and bad news in considering tracking at large hour angles. We have just discovered the bad news. The good news is most interesting. At large hour angles, refraction in the Earth's atmosphere raises an object under observation. On an equatorial mount of regular construction, this requires correction on two axes. With the Poncet unit, movement on the altitude of the alt-azimuth part will correct this effect without further changes.





Is this mount the answer to tracking with Dobsonian telescopes with their large apertures? As the Dobsonian is already on an alt-azimuth mount, all that is necessary to convert to equatorial tracking is to modify the base plate or ground board. Put two feet on one end of the bottom of the mount, which will then become the north end, and at the opposite end place a support in which is located the rotational nut and cover plate making up the pivot and south end. Add a new ground plate upon which is put a support onto which is screwed the bolt that will become the polar axis pivot. On the new plate, opposite this bolt, locate the tilted planes for the feet to slide upon. Add the tangent arm drive and if one must keep the cost down, use a manual drive to the threaded rod by means of a flexible shaft or a jointed system of solid rods.

The several-inch increase of the height of the instrument off the ground is a small price to pay for the ability to track for an hour. A more serious potential objection lies in constructing a sufficiently stable and solid platform so as not to lose the inherent stability of the Dobsonian design. Certainly any conversion of this sort should not be undertaken without leaving the road open to use the original mount unchanged.

In the March 1980 *Sky & Telescope*, Mr. Poncet suggests a large equatorial platform that would carry not only heavy equipment but the observer or observing party. I've been toying with this idea since 1977 when I first read of the design. Our local astronomy club, the McDonnell Douglas Astronomers Club, frequently presents lectures on astronomy for local organizations. Whenever possible, we include a stargazing party through member telescopes. Sometimes it is inconvenient for members to come out with telescopes and the observing has to be restricted or dropped entirely. However, a platform large enough to carry several telescopes and observers could eliminate the need for any others to come out — and the result would be the title for this presentation: "Have Telescopes Will Travel."

In the next issue of TM the plans for a Poncet mount made with simple hand tools will be presented. It's one capable of carrying a 6-inch Newtonian for many hours of pleasurable observing.

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How to Control Friction in a Dobsonian Telescope

Introduction

Dobsonian telescopes depend on the friction in their bearings to function correctly. They have, if properly constructed, enough friction to hold them in place against a moderate imbalance and normal wind pressures, but little enough that a light touch on the tube near the eyepiece is sufficient to move the telescope to follow a star.

The problem, then, is to design the telescope so that it has the right amount of friction. Today designing Dobsonians is done like designing opera halls was in the last century: when someone builds a good one, you copy it. Nevertheless, while you can be fairly certain of getting good performance by faithfully copying a successful Dobsonian, you can't proceed with any certainty to build a new or different Dobsonian.

This article presents a method for calculating the force required to move a Dobsonian telescope that should help you design one, especially if you're planning a large, long, heavy, short, light, or small Dobsonian.

Calculating the "Push"

Dobsonians are very easy to aim and point from the eyepiece end. Ideally the force required to move the telescope is the same in all directions, but for purposes of calculation, we'll divide this force into two components: one into or away from the eyepiece for azimuth motion, and another in the vertical plane perpendicular to the long dimension of the telescope tube, for altitude motion.

We will now find the azimuth component. Let R_z be the radius of the azimuth bearing, W_z be the combined weight of the telescope and rocker, and A, the altitude angle of the telescope. If L is the length of the telescope between the side bearing and the eyepiece, then Lcos(A) is the moment arm of the eyepiece about the center of the azimuth bearing.

Given the coefficient of friction — f — between the materials of the bearing, then $fW_z/3$ is the force necessary to move one bearing pad in a straight line, and fW_zR_z is the torque required to rotate the bearing.

If F_z is the force at the eyepiece to move the telescope in azimuth, then $F_zLcos(A)$ is the torque applied to the bearing. It follows then, that:

$$F_z = fW_zR_z/(Lcos(A))$$

A similar derivation is made for the altitude force, F_a. Let R_a be the radius of the altitude bearing; W_a, the weight of the telescope and tube box; and theta, the semi-angle between the bearing pads. Because the weight of the telescope is not normal to the pads, we find the normal force, N, equal to $(W_asec(theta))/4$ on a single pad (assuming, of course, that there are four pads). The frictional force at each pad is fN, and the torque to rotate the bearing is $4fNR_a$. The torque applied to the bearing by the observer at the eyepeice is F_aL, and it follows that:

$$F_a = fW_asec(theta)R_a/L$$

For example, calculate the forces for a 16″ f/5 Dobsonian, given the following: R_z=9″, W_z=120 lbs, A=45°, L=40″, and f=0.083 (teflon/formica); the azimuth force is:

$$F_z = 0.083(120)9/(0.7)40 = 3.2 \text{ lbs}$$

In altitude, R_a=4″, W_a=80 lbs, theta=60°, f=0.13 (PVC/teflon). The force is therefore:

$$F_a = 0.13(80)2.0(4)/40 = 2.1 \text{ lbs}$$

In each case, there are three factors controlling the force required to move the telescope: 1) the coefficient of friction, due to the materials in the bearing, 2) the loading, due to the weight of the telescope and the geometry of the bearing, and 3) the ratio between the moment arm of the telescope and the radius of the bearing.

The Coefficient of Friction

The coefficient of kinetic friction, for one material sliding on another at rest, is equal to the normal force, N, between the surfaces divided by the force of friction, F:

$$f = N/F$$

The coefficient of static friction, the same ratio for non-moving surfaces, is measured at the moment one surface starts sliding on the other. Kinetic friction is always less than static friction, and both are usually less than 1.

Since the coefficients of friction between materials typical of Dobsonian telescopes are not found listed in the engineering handbooks, these were determined with a triangular sled with feet made of one test material. It carried a known weight, and was drawn across a sample of the other test material. The force required to start the sled moving and to move the sled at a constant speed was measured with a spring scale. The results are presented in Table 1.

Kinetic friction, according to the textbooks, is: 1) directly proportional to the pressure, 2) constant for all pressures, and 3) independent of the area of contact. These are approximately true for "normal" materials and also for the materials used in the bearings of Dobsonians. This

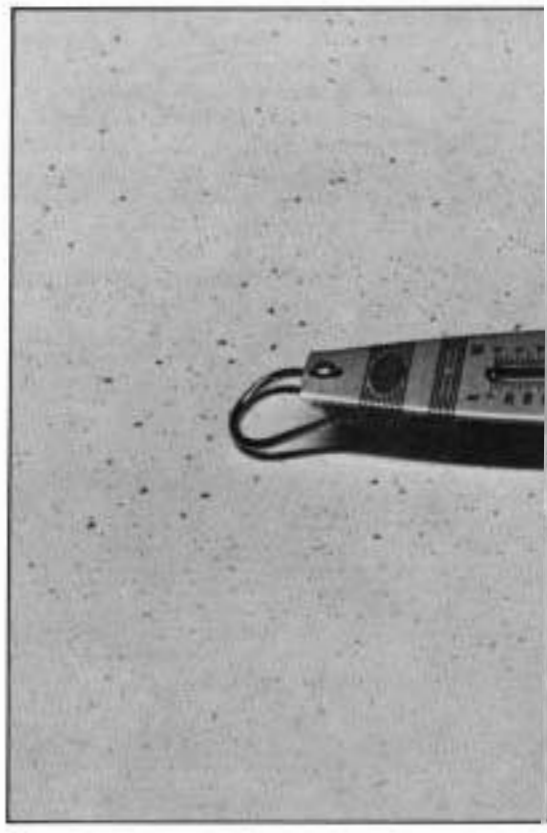
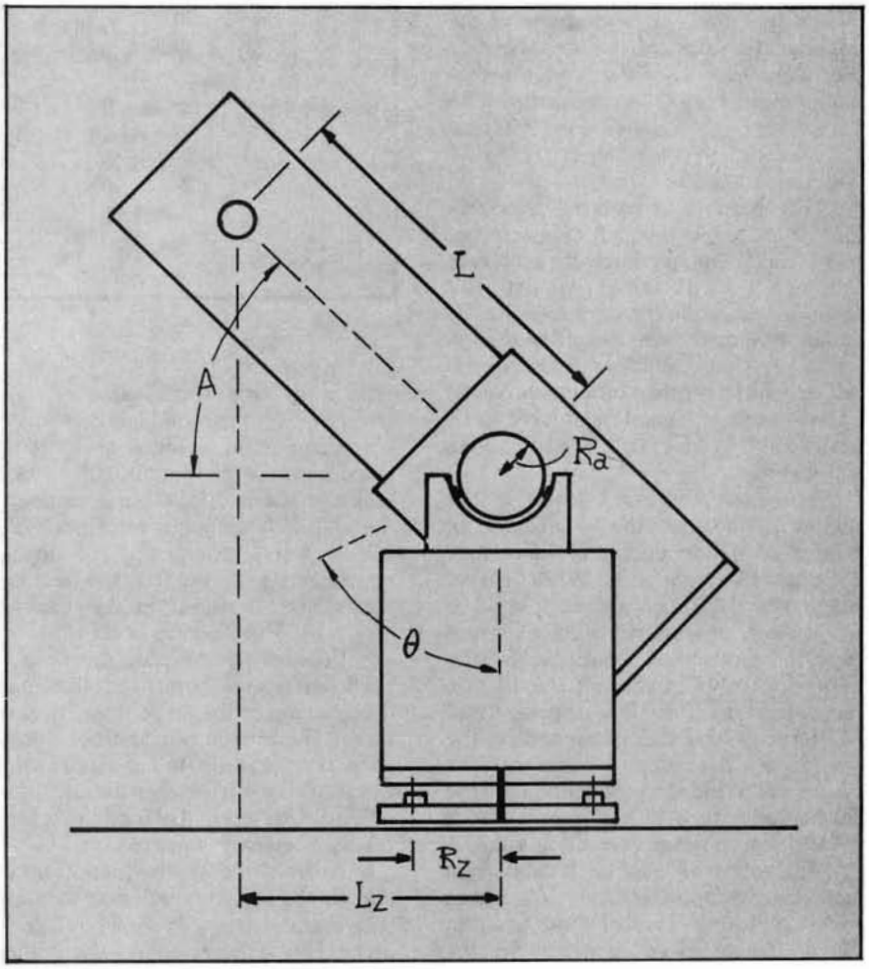
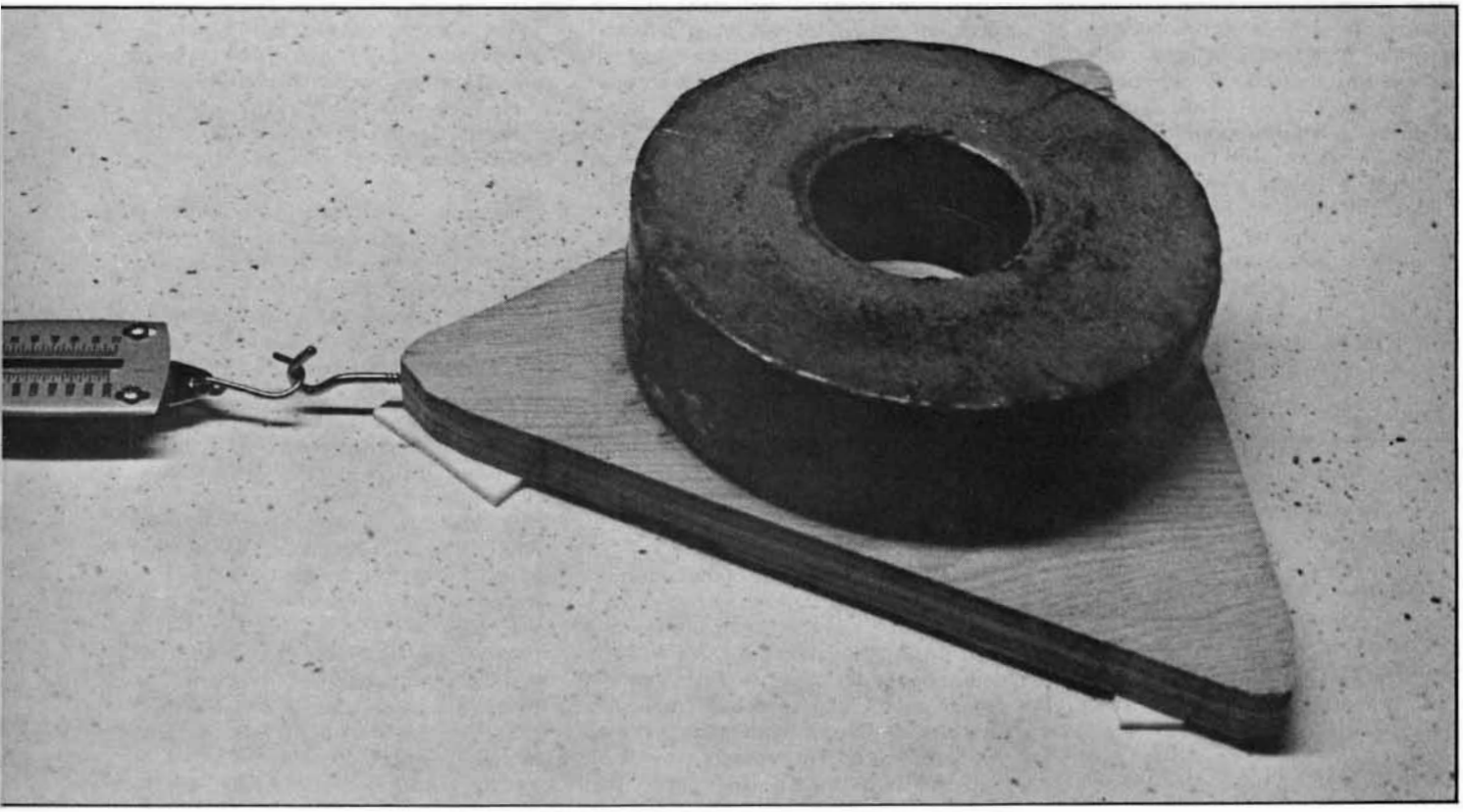


TABLE 1
Coefficients of Friction

Dobsonian materials	static	kinetic*
teflon/nylon	0.055	0.050**
teflon/formica	0.105	0.083**
teflon/aluminum	0.12	0.095**
teflon/PVC	0.13	0.13
nylon/aluminum	0.13	0.125**
nylon/formica	0.20	0.19
PVC/formica	0.25	0.17
PVC/plywood	0.28	0.23
roll-disk/masonite	0.22	0.19
felt/formica	0.23	0.22
felt/aluminum	0.31	0.31**
plywood/formica	0.37	0.20
plywood/particle board	0.45	0.30
Other materials		**kinetic**
steel/steel		0.58
metal/soapy wood		0.20
metal/oiled leather		0.15
steel/oiled agate		0.11
ski wax/snow		0.04
steel/ice		0.01

* at a relative velocity of 1 mm/sec
** depends on relative velocity





means that the size and shape of the bearing pads does not matter so long as the pressures are low enough that materials such as teflon and formica do not wear too rapidly. For classical Dobsonians, this loading is 10 to 30 pounds per square inch.

The number of materials available for the pads gives you friction control over a 3:1 range through materials choice — but what about the teflon/formica combination explains its superior performance? Note that though teflon has a low coefficient of friction, it is not *enough* lower than other materials to make it unique. Teflon must have some unusual property besides its slipperiness.

An additional point made in the textbooks is that the coefficient of friction is: 4) independent of the relative velocity of the surfaces. While true of many materials, such as wood/wood or wood/steel, it is *not* true of the materials used in Dobsonian bearings. In the course of the coefficient of friction measurements, it became apparent that the force on the sled depended on the speed of the sled. Therefore the coefficient of friction is dependent on the relative velocity of the materials. Data for teflon/formica are presented in Table 2.

For teflon/formica, each doubling of speed means approximately 10% higher frictional force. The bearing acts, in effect, like a *speed regulator* for the telescope. When you apply an initial force great enough to overcome the static friction, the telescope accelerates until the pads reach a linear velocity sufficient to resist that force. Thereafter the telescope moves at a constant angular speed unless more force is used.

Contrast this with the performance of "normal" bearing materials. When force sufficient to overcome the static friction is applied, the telescope accelerates and continues to accelerate. Because the kinetic friction remains constant, unless you actively control the force, the telescope does not move at a constant rate. Such telescopes tend to "run away" from the observer.

TABLE 2
The Effect of Velocity on Friction
teflon/formica

relative velocity (mm/sec)	coefficient of friction
static	0.105
1.0	0.083
2.3	0.090
4.2	0.10
8.5	0.11
17.	0.12
60.	0.15
225.	0.20

TABLE 3
Wind Velocity Pressure

Pressure (miles/hour)	Pressure (lbs/ft²)	Shape Factors	
5	0.06	flat plate	1.1
10	0.26	prism	1.5
15	.58	cylinder	0.7
20	1.02	wire	1.2
25	1.60	square beam	2.0
30	2.30	cube	0.8

One of the combinations tested, nylon/aluminum, showed an extremely rapid increase of friction with velocity, which made it unsuitable as a bearing material. While a good performer at slow speeds, the coefficient of friction increases so sharply that the bearing is sticky, and "chatters", at higher speeds.

The Bearing Load

Friction in the side bearings, in particular, can be controlled by changing the spacing, or the angle theta, between them. The friction is proportional to the secant of the angle, and gives you a 1.7:1 range of control (between theta = 30° and 60°) over the amount of friction. At larger thetas, the shaft tends to jam.

At small thetas, the friction on one pad can be great enough that sliding will stop and the axle will rotate off the other pad. This can happen when theta, measured in radians, becomes less than the coefficient of friction; or approximately 6° for very low speeds and 10° for slewing. However, because of the torques generated when the telescope is accelerated, 30° is probably the lowest safe value of theta.

If you have built conventional telescopes with lubricated metal/metal or roller bearings, you had to add friction with clamps or clutches. Drag in these additional friction devices does not depend on the telescope's weight.

In a Dobsonian, remember that weight is an important factor in how readily the instrument moves. By careful choice of mirror weight, tube material, thickness, and cross-section, and the use of lightweight components, the designer can vary the weight of a telescope over a range as large as 3:1 for control of friction.

Bearing Size Factor

While the linear size of the bearing in a Dobsonian is usually specified, it is actually the ratio between the bearing size and the moment arm of the telescope that matters. Side bearings range from 4" diameter to 24", and you'll encounter bottom bearings as large as 40" in diameter. The moment arm can be as small as 16" for a 6" RFT and as large as 180" for a 24" f/8 telescope with a thin mirror. The ratio can be varied with ease over a 4:1 range. Clearly, this is a powerful design tool.

There are limits, however. If the bottom bearing is made small, it may be unstable and the telescope may tip when rotated. Moreover, if the bearings are small relative to the moment arm, the linear velocity of the teflon may not become high enough for teflon's regulating effect to occur, and the "buttery" feel characteristic of Dobsonians will be lost. The teflon then serves merely as a slippery surface.

On the other hand, it's taken as a rule of thumb that the bottom bearing should be at least the diameter of the mirror. However, it is not necessarily true that bigger is better, because in large instruments, this may lead to more friction than desirable.

How Much Friction is Right?

How much friction is right? Table 4 lists the force necessary to move several Dobsonians from the vicinity of the eyepiece holder. These were measured with a spring scale at the 1980 Riverside Telescope Makers Conference. Generally, a force between 2 and 4 pounds seems to be satisfactory, although 8 to 10 pounds is not objectionable if the resulting motion is very smooth. One pound is about the lower limit for good control of medium-size telescopes, but is quite satisfactory for small telescopes. It is desirable to make the forces in altitude and azimuth equal, or nearly so, because the sense of gliding effortlessly through space is enhanced when the telescope moves without preferred directions. Because the azimuth force varies with the altitude of the telescope, set them equal at A=45°.

However, there are several lower limits that must be considered. The wind exerts a pressure on the telescope that depends on the square of the wind velocity (see Table 3). Choose a reasonable value for the upper limit you'd find acceptable for observing, and figure out the number of square feet of telescope tube not balanced about the bearing. Multiply this by the shape factor and the wind pressure to obtain the force on the tube. For a 16" f/5 in a 20 m.p.h.

wind, the wind force is about 2 pounds. For a 24″ f/8, it is 16 lbs.

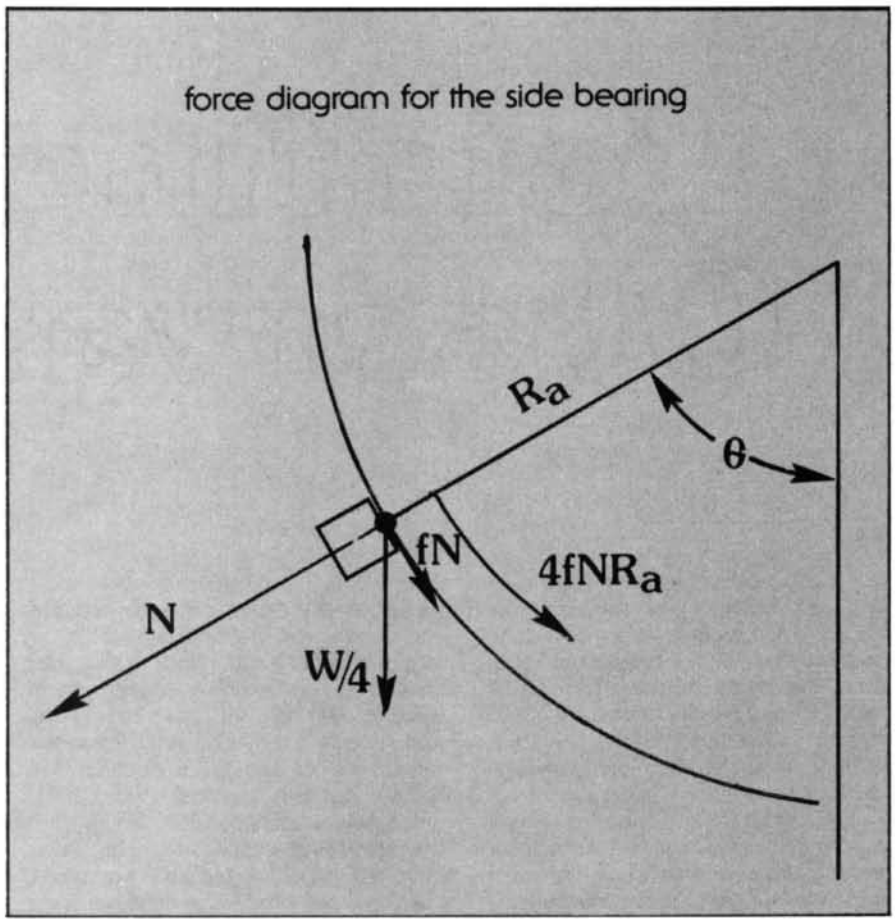
Air flowing past a cylinder (your telescope tube) generates downwind eddies. The eddy frequency is roughly:
f(Hz) = 0.3 x V(in miles per hour)/D(in feet),
where V is the wind speed and D is the diameter of the tube. The tube will have periodic forces on it, at the eddy frequency, which may cause it to vibrate, especially if its natural frequency is near the eddy frequency. While a stubby 16″ may not shake at 4 Hz, a long 24″ might well shake at 2 Hz.

Finally, measure the differences between the weights of the eyepieces you use frequently, and do not design a telescope that moves spontaneously whenever the eyepiece is changed. This is especially important if you use big Erfles.

Conclusion

The equations show that the usual design approach — simply scaling the entire telescope up — is not appropriate. What is necessary is a full evaluation of the performance desired, the tradeoffs between weight and stiffness in the tube and mount, available materials, and stability.

Consider scaling a 12″ f/6 telescope with 8″ diameter PVC/plywood side bearings that moves with what you consider the ideal amount of force. In scaling this design to a 24″ f/4.5, if you simply double thicknesses and dimensions, the weight will increase by a factor between the square and cube of 2; let us say (for the sake of argument) by a factor of 6. Simply doubling the diameter of the side bearing to 16″ will not give the same feel: since the force necessary to move the instrument will increase by a factor of about 5.



The appropriate response is not necessarily to make the side bearing smaller — in this case to reduce it to 2″. First, consider a lightweight mirror, which in turn makes possible lightening the tube and rocker. Then consider a change of materials: instead of PVC/wood, consider switching to PVC/teflon. A 12″ diameter side bearing would be a good compromise. Check whether the angle between the pads can be reduced. Calculate the wind forces on the larger tube, and recognize that (perhaps) a bigger telescope should not move as easily as a smaller one. In any case, you've probably already succeeded in reducing the friction to an acceptable level. For telescopes exceeding 24″, you might experiment with bearing materials such as teflon/nylon.

I would like to see others, better equipped for such work, carry out more complete experiments on friction between teflon, formica, and other materials suitable for use in Dobsonians. It would also be interesting if a home computer buff with a bent for physics would calculate curves for force, position, velocity, and acceleration of telescopes, with and without velocity-dependent friction in the bearings, and model for us the optimum size bearings for tracking manually.

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TABLE 4
Forces Required for Various Telescopes

owner	telescope	az.	alt.	comments
	Too easy, one or both axes			
Berry	10″ f/5	1.4	0.3	alt too easy
Kestner	8″ f/7	1.3	0.6	alt too easy
Guthmiller	10″ f/9	0.4	0.5	much too easy
Chandler	12″ f/4	1.5	1.0	both too easy
	Good motion, firm but easy			
Kestner	12″ f/6	3.9	2.0	very nice
Donnally	8″ f/8	2.7	1.5	excellent
Ferguson	16″ f/5	6.	2.8	very nice
Edmund	Astroscan	0.8	1.0	right for 4″
	Too heavy, one or both axes			
Jacobsen	13″ f/4.5	8.	3.4	prototype
Berry	20″ f/5	10.	6.	okay for 20″

A Rotating Shed Observatory

My first telescope was a 6½" reflector with a longish focal length — the tube being 68-inches long — on an alt-azimuth mount. My "friends" informed me it would be more comfortable for them to use it if it was housed in an observatory to give them shelter from cold winds!

Always ready to oblige, I set about building one for them. Living in a village, as I do, one has the advantage of knowing, and taking advantage of, local tradesmen like the plumber, the builder, the carpenter, etc., for those little odds and ends when constructing this and that.

My idea was to have a "total rotator" so I could open the door and walk in without climbing over, or ducking under. This called for a circular track on the concrete base. I consulted the local blacksmith: a seven-foot diameter track of 2" x 1" angle iron? That would mean forging over 20' of material, he said. His suggestion was, if I was agreeable, to fabricate short lengths (four or five feet) curved in his bending machine and welded. This proved most successful, and so very much cheaper. I have the receipt before me for 8 pounds ($16 today). But this was in October 1971, nearly ten years ago; I don't know what the rate of exchange was then, but it was quite a small outlay for what I required. He also made eight "h" section housings to hold 3½" diameter wheels.

Next, a rigid base was essential. I constructed it from a frame of 3" x 2" timber seven feet square with diagonals at the corners to form an inside octagon, half-jointed, with plenty of screws.

A light second-hand door was obtained from the builder who was knocking an old house down. This was 30" wide. A word of advice: Don't have the door too narrow. Apparatus, like stands to get in and out, can be wider than you think.

The door frame was the first of the uprights, then the corner posts and other verticals well-braced with diagonals. I arranged the roof joists so that an opening with hinged flap could be incorporated to give 90° of view — from the horizontal to the zenith — and provide sufficient slope to decant rainfall.

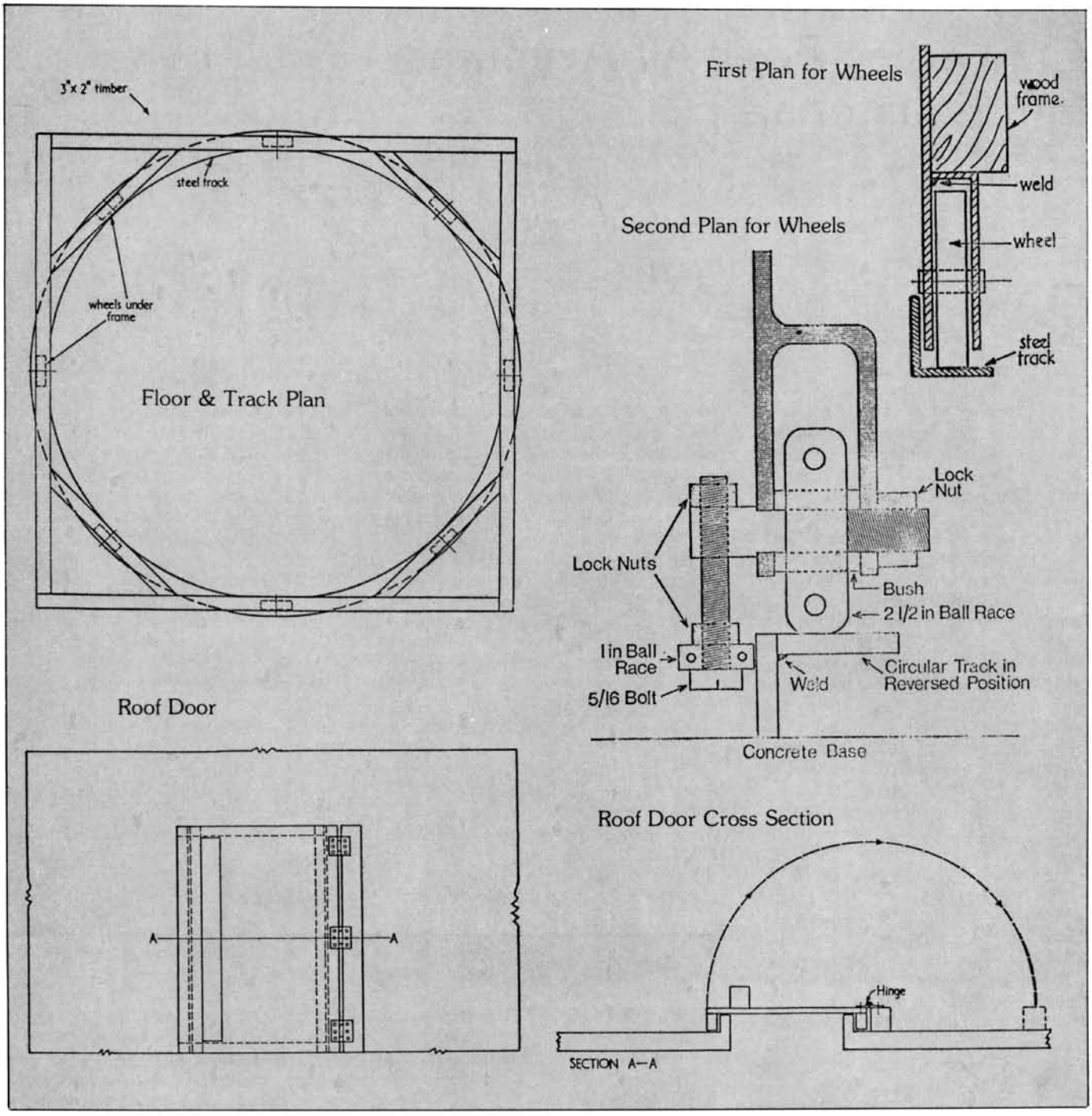
A square building is the easiest to construct — six, eight, or more sides, or round (still more difficult) in that order. Most difficult of all is the classical domed building. Have you come across a dome that did not have problems with weatherproofing? I have not. Why a dome anyway? I have seven feet of head room everywhere in the observatory. It has been erected now for nearly ten years and has stood up to force - 10 gales. (Selsey Bill, where I live, sticks well out into the English Channel, and I am only five minutes walk from the sea.)

When I came here there was an elderly shed in the garden and that, using the best of its timber, provided the sides and the roof. Paint the sides, install roofing felt on top, and it looks like the garden shed in millions of homes up and down the country.

A length of steel rod attached to the underside of the roof flap helps me to lift it to just over the point of balance, and ease it down to lay flat on the roof. It also aids recovery.

Arranging proper rotation for the building presented some difficulties. At first, I placed the angle iron track on the concrete, flat side down. The large wheels ran on the outer side, the small wheels were fitted to keep it central, but this did not entirely keep them from rubbing against the sides. There was room for improvement.

A visit to my friend at the local



scrapyard soon provided the means: ball-races. Eight 2" and eight 1" cost just two dollars. Then I realized the solution was to turn the track over so the flat was on top. But the building was already built. I carefully levered up the observatory with plenty of blocks handy. Just going round and round, a foot or so at a time, it was no problem. So I drew the track out, turned it over, slid it back, and refitted brackets with modified roller-bearing wheels and small ball-races in place to keep it central.

The large wheels are now free of any side contact and behave perfectly. Kept well-lubricated, rotation can be effected with almost finger touch. There is just sufficient clearance between the sides and the concrete base, and the steel track just lying on the floor is barrier enough to keep out any rain that tries to drift in.

I found that if I put flooring over the corner triangles, it strengthened the base frame still more and prevented feet being caught, and accidents in the dark, and was a useful ledge for mirror covers, etc. I hope the diagrams and pictures will make everything quite clear.

Should anyone care to copy this idea, may I suggest a simple short cut: It would possibly be easier, and cheaper, to buy one of those potting sheds, or garden sheds, from the garden center stores. For the base frame, cut a frame to fit, and modify the roof to taste. If it is, say, 8'x 6', what matter — it doesn't have to be square so long as it is big enough.

Nor does it necessarily have to have a metal track. A friend of mine has a similar one set up on pram wheels; it doesn't, after all, have to whiz around. 15° an hour is the usual speed.

Cherri-o-good chap!

Reg Spry
60 Windsor Road
Selsey P020 0AU
Sussex, England

Converting Fork Alt-Azimuths into Equatorials

One of the chief difficulties with inexpensive imported refractors is that they are usually mounted on shaky, unstable fork-type alt-azimuth mounts. From my experience, these mounts are unsuitable for celestial observation above 30x (and how infrequently such telescopes come with an eyepiece with magnification that low!). The two independent adjustments required to follow a celestial object with such a mount are very frustrating to novice observers, and often cause even the optically adequate refractors to be reboxed. Worst of all, they can turn their owners away from astronomy. Isn't there an inexpensive and easy way to convert these telescopes to a stabler and simpler mount, such as an equatorial?

In designing such a mount, I tried to achieve several goals: 1) use as much as possible of the existing mount; 2) be able to convert the equatorial back to alt-azimuth for terrestrial use; 3) be able to balance the scope if accessories are added; 4) be adaptable to any U.S. latitude; 5) offer considerably smoother and sturdier operation than the original mount; and 6) do all this for under $10 and with less than four hours construction time.

As Sam Brown so often noted, pipe fittings are the cheapest and simplest mounts. For 60 mm refractors, I believe ¾" pipe size is sufficient, but if extra stability is desired, go up to 1" size. Buy two floor flanges, two closed union joints, a 6" long threaded pipe, and 2 Ts. Smooth motion in these joints is, of course, facilitated by working the joints for several minutes with carborundum grit (#120 works well) with oil for lubricant. Once smooth enough, rinse with gasoline and lubricate with a heavy grease for smooth operation (don't smoke while rinsing!).

To convert the alt-azimuth, first loosen the clamping bolts which hold the telescope tube in the fork. The tube will later be remounted on a cradle. Next, cut a solid wood block to the width of the fork. It may need an extension on the back at lower latitudes. It helps to saw out and file the wood block to fit the contours of the bottom of the fork for a snug fit later. A wood screw and washer will be used to anchor the bottom of the latitude block in place.

The most crucial adjustment for the block is getting the tilt to match your latitude. Its face should be tilted from the vertical by the number of degrees of your local latitude. To do this, I taped a protractor to the side of the block and used a weighted line to find this tilt accurately. If you come close, you can always adjust the tripod legs exactly later.

Once you have the correct tilt of this block, tighten the fork bolts until they make an impression in the block. Using these marks, drill slightly undersized holes and carefully thread the bolts into the wood; it may help to remove the bolts from the wood to do this. Now paint the block, if desired. Mount it in the fork with bolts through the fork and a wood screw in the back. Next, mount one of the flanges on the front of the block with wood screws. This flange should point directly to Polaris when properly set.

Ideally the azimuth rotation of the fork could be retained to help set the scope on Polaris, but in the conversions I have done, the clamping bolt on the azimuth was a bad source of wobble. I added tape for a bushing, and tapped the metal axis for the threads of the clamping bolt. When it's tightened into the tapped hole, this annoying source of play is eliminated. Now the whole telescope must be picked up for polar alignment, however. Check to see how bad a problem this wobble is in your scope before doing this part of the conversion since it may not be needed. In any case, loosening the azimuth clamping bolt returns the scope to its original configuration.

For the telescope saddle I used a piece of ¼″ plywood 12″ long and 3″ wide. The second flange is mounted in the center of the board with wood screws. When it pivots on top of the T-joint, this flange forms the declination axis. I used a scroll saw to cut out two cradles of softwood to support the scope tube at both ends, but if your tube came packed in foam fittings, it's easy to glue these to the ends of the saddle instead. Clamping the tube to the cradle and saddle can be done as shown in the photographs, or with a large hose clamp, lined with felt and bolted to the center of the saddle.

Since this is a "German" equatorial, you'll need a counterweight opposite the tube. Screw the pipe fittings together, with the 6″ pipe below the T-joint. If convenient, and you have metal weights handy, add enough to balance the tube. I resorted, instead, to drilling a 1″ hole through several large pieces of scrap wood, adding enough to balance the tube, then holding the nailed-together counterweight at the balance point with a bolt threaded through the wood from the front. Be sure the counterweight will clear the tripod legs.

Some of the photos show an "el" threaded to the bottom of the 6″ pipe, with a 6″ wood stick in the other end. Later I found it more convenient to use another T with two sticks. These sticks provide control arms for smooth motion in R.A. once the object is located. The scope tube doesn't have to be touched to track, a real advantage at higher powers.

In converting this 80 mm Jaegers refractor into a better performer, I bought my own 1¼″ diagonal and use 1¼″ eyepieces, which are superior optically to Japanese Huygens eyepieces. Commercial diagonals are available for under $20. I also strengthened the tripod legs by substituting a ¼″ thick plywood triangle for the flimsy metal eyepiece rack supplied. The rack provided room for three standard-size eyepiece holes. Also I added three cup hooks, wire, and a turnbuckle to strengthen and tighten the tripod legs for extra sturdiness.

The total expense of these modifications was less than $10, and it took only four hours. No tools other than a drill, hammer, screw driver, and wrench are needed. For the millions of owners of alt-azimuth refractors like the one shown, this smooth, light equatorial mount sure makes looking up a lot easier.

Dr. J. Wayne Wooten
Assistant Professor of Astronomy
Pensacola Junior College

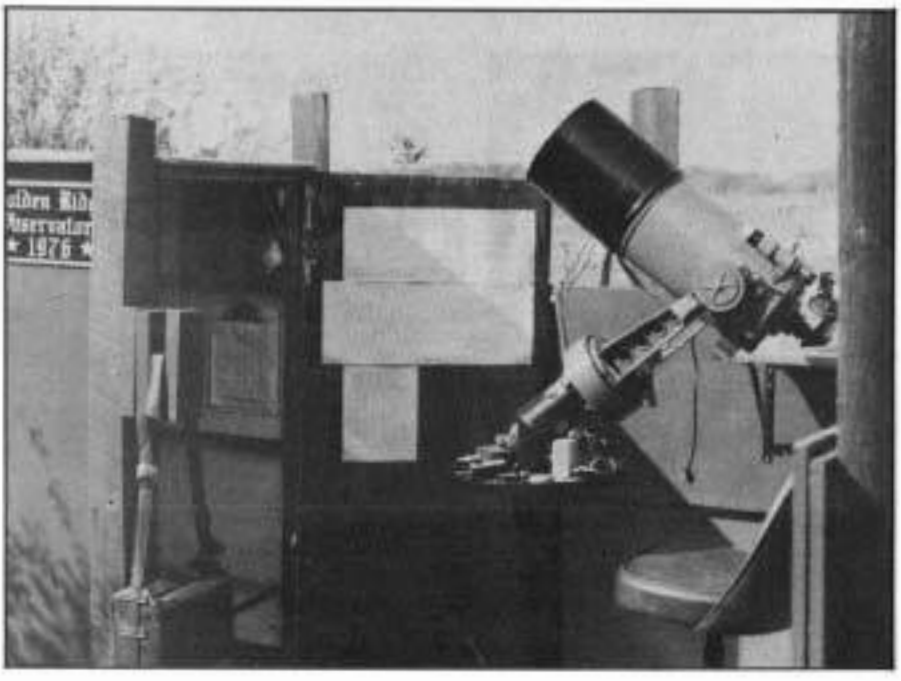
Golden Ridge Observatory

If you are an amateur astronomer who has a small or compact telescope and doesn't like the inconvenience of setting up for each observing session, you might consider building a small and relatively inexpensive observatory like mine. Such a structure allows you to easily begin and end observation, and yet provides your equipment the full protection it deserves. It also allows you to be permanently aligned for quick finding of deep-sky objects and/or astrophotography. My observatory design has a further asset: most of the unit can be disassembled if a move to a new location ever becomes necessary.

Before completion of my present observatory, I had changed my mind many times how to build and what materials I would use. With suggestions and help from my parents, my two twin foster brothers, and friend Kent Brenton of the Evansville Astronomical Society, I developed a model which gives my equipment full protection from the elements and makes for a great deal of fun to use.

During the incubation period — about ten months — I ran the gamut from planning a prefabricated metal shed with a run-off roof, using such a building as a run-off shed, using glass storm doors with a run-off roof, to constructing a frame to support a canvas as a protective covering. Because I am not very mechanical or handy with lumber, I was in a quandary.

The result of my long deliberations is a frame made of 1⅛″ punched angle iron which my father supplied from his farm. Today the cost of such might be prohibitive, but the frame for a run-off shed could also be made of wood or the angle iron provided with steel shelving. This run-off "chest" has the dimensions: 4′6″ high, 4′2″ long, and 2′1″ wide. The side covering is ⅝″ exterior plywood with ¾″ exterior plywood on top. The middle of the roof was bridged so that dew and rain run off well. Three shelves inside facilitate notetaking and storage of accessories. All of this simply rolls on 4″ rubber rollers mounted at the bottom of the frame. It rolls so easily and accurately that no tracks (over which to stumble) are necessary.

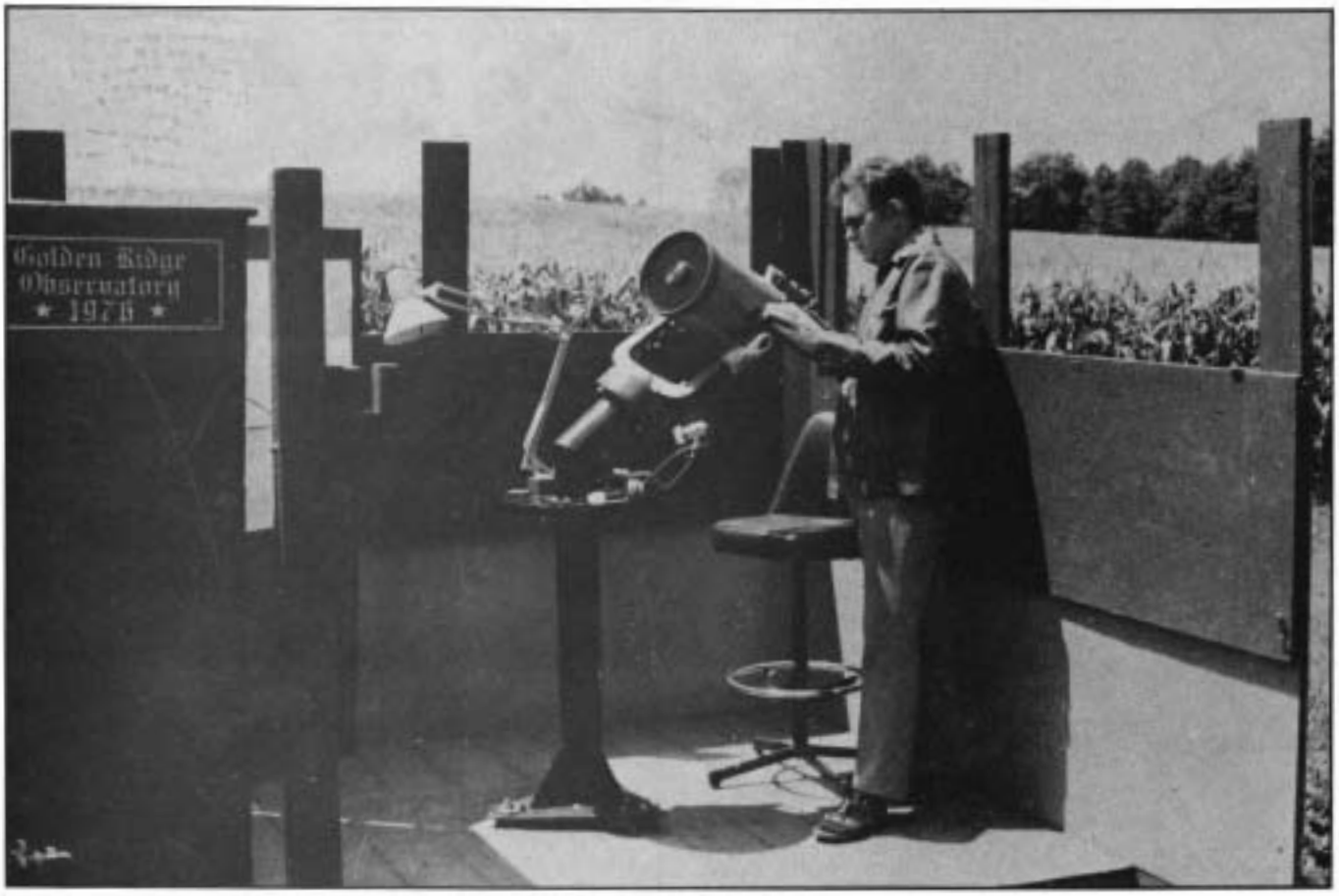


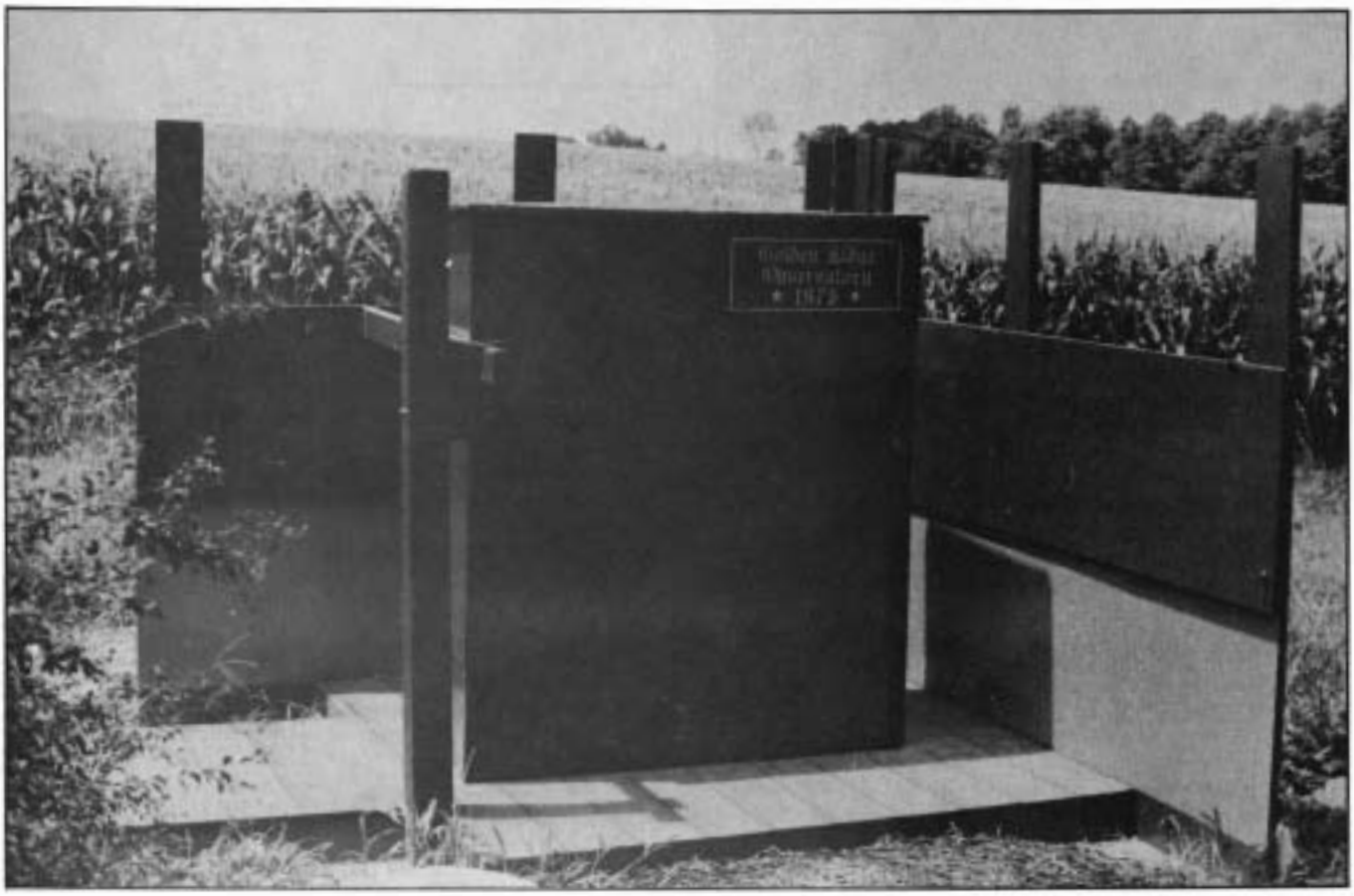
For wind protection, a canvas wind barrier could be set up around the outside of the platform to deter prevailing winds, but I used ½″ exterior plywood to construct a hinged wall so that the obstruction can be eliminated when necessary by folding the top down.

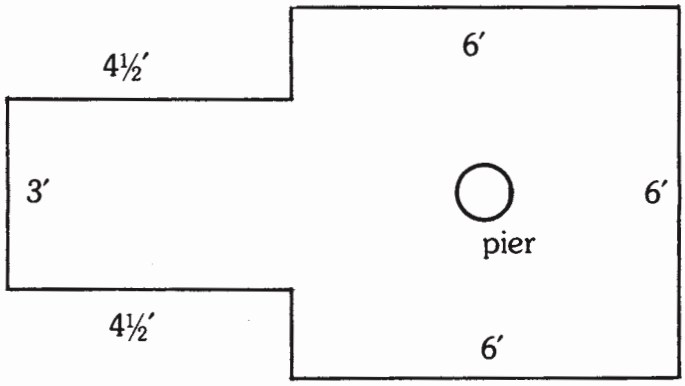
When the observatory is pushed aside to reveal the telescope, I use the protection afforded by the "chest" to peruse star atlases or simply warm myself with the infrared heater inside while the telescope is set on automatic tracking for astrophotography. By the way, the infrared heater heats only the objects it hits such as one's feet without disturbing the surrounding atmosphere greatly. While inside, I can use the bottom shelf to keep my feet off the cold floor. Otherwise the bottom shelf is used to store a small stool and the heater which ride to and fro as the shed is positioned. The middle shelf serves as a desk, and the top for books, atlases and other accessories. I've got everything there but running water!

The pier which holds my Celestron 8 and homemade 5-inch richest field refractor was adapted from the plans provided by Celestron. The custom work done by a local welding shop includes a bottom plate for accurate polar alignment, a 17″ accessory shelf, and an electrical outlet mounted in the 4-inch pipe above the shelf, eliminating all external wires. I took the pier to the welding shop a total of four times before I could not think of anything else to have done to it. The completed pier cost $98.00.

Except for the angled section at the top, the pier was filled with dry sand. Several small stones were placed at the bottom to allow eventual condensation to drain preventing internal corrosion. I


Golden Ridge
Observatory
★ 1976 ★





filled the angled section at the top with plaster of Paris because it is lighter than sand and thus allows the center of gravity to be as low and near the vertical as possible. A three-inch thick plug of plaster of Paris capped off the bottom of the pipe so that I can easily remove the sand if ever needed. I embedded a ¾″ conduit in the sand and plaster of Paris to accommodate the electrical wiring. The total weight of pier with sand is 102 pounds.

The base for the pier was made with three ¾″ x 3′ long threaded rods embedded in concrete. This is certainly much more than needed, but later a larger telescope could be used on the same foundation. To keep alignment accurate while pouring and curing the concrete, the rods were held in place by two metal templates. On January 14, 1976, a time capsule was placed at the north side of the foundation. The shelter rolls on a 6′ by 6′ by 4½′ by 3′ redwood tongue and groved floor. The floor is not strictly necessary, but concrete is cold, and, if one is involved in astrophotography, the concrete floor should be isolated from the pier base to prevent vibrations from walking on the floor from shaking the telescope.

I think I have at least a scintilla of evidence that easy accessibility to an accurately aligned telescope makes for success in astronomy. From July 14, 1976 to September 23, 1976, I was able to find and log 95 Messier objects, numerous NGCs, and multiple star systems during 18 observing sessions — while also having fun observing comets West and d'Arrest. By using the setting circles on my Celestron 8, it was no real problem to ferret galaxies out of the Virgo and Coma clusters. A great help in notetaking is using a mini-cassette tape recorder. I find I can observe an object while giving an immediate description. Then at a later time, I enter my notes into the log book. My handwriting is bad enough in daylight — without having to try writing in near darkness.

The principal eyepieces used were a 16 mm Koenig from Japan bought through University Optics and a Clave Plossl from France through Cross Optics. I bought the eyepiece turret from Unitron to expedite viewing. Because I was a German instructor at Reitz High School in Evansville, Indiana, I soon plan to have several eyepieces from Germany. I now own six Clave Plossl eyepieces.

During September 1976, I assembled a 5″ RFT refractor from Jaeger parts. I plan to buy an equatorial mount for this scope for observing. For photography through the Celestron I have an off-axis guider.

Final Note: On September 26, 1976, I held an open house and dedication of Golden Ridge Observatory for friends. I gave a half hour lecture about the observatory with 69 people present. The rest of the afternoon was spent in fun and games and a buffet for supper.

Norman L. Happe
R. 1, Box 257
Wadesville, IN 47638

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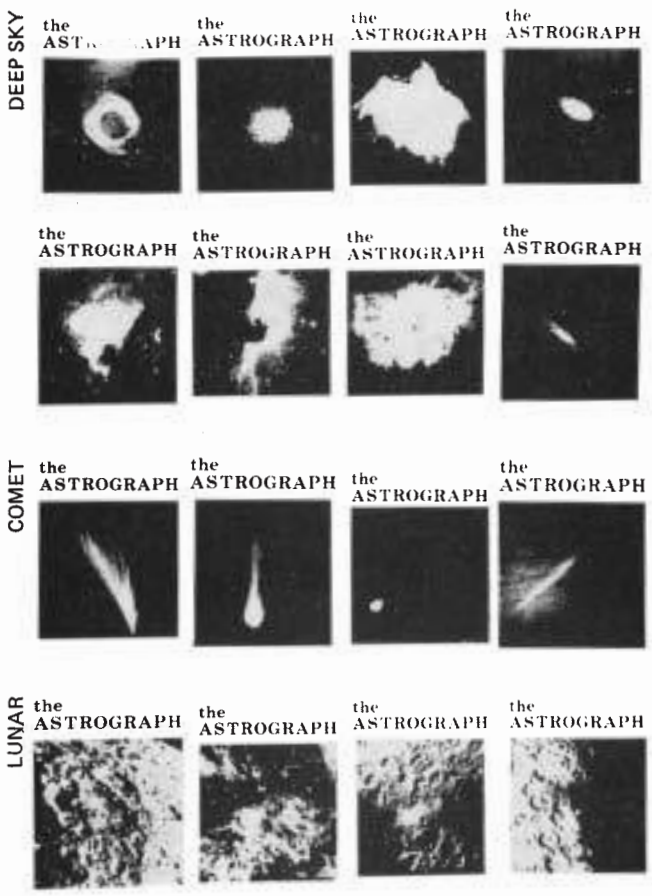

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Letters

Glass Supply Problem

Dear Readers / I recently received some unfortunate news relative to raw glass for the Jones/Bird or the glass for refractive elements: Glass Brokers now have a minimum charge of $20 on all orders! They will not process any orders for less and will return all checks below that amount. The amateur will have to pool orders, with several getting together to get up the necessary $20 minimum if they want glass from them. Unfortunately, virtually every firm is now doing this so there is no other source now available with no minimum charge.

Robert E. Cox

Wire Test Not So New

Dear Sirs / Your description of the wire test (TM #6) was not entirely accurate. James Kent might have discovered the wire test independently, but he wasn't the first. It has been around for at least forty years and available in public journals. R. Platzeck and E. Gaviola fully describe it in the article in which they develop what is now called the "caustic test" (*J. Opt. Soc. Am.*, vol. 29, page 484, 1939). Another description of the same test is given by A. S. DeVany (*Applied Optics*, vol. 9, no. 7, July 1970).

These articles are worthwhile reading for anyone interested in the relationships between various different tests: Foucault, "caustic," Ronchi, and wire tests of various sorts.

Bill McKinley
3822 Shelby Rd.
Lynnwood, WA 98036

Soviet Recognition

Dear Sirs / The Institute of Scientific Information of the USSR Academy of Sciences publishes issues of the *Abstracts Journal* in 25 series in which we review Soviet and foreign literature, both periodical and non-periodical, in all fields of natural and applied science and technology. Thus, our *Journal* is a most comprehensive scientific and bibliographical publication. It also largely contributes to publicizing books, monographs and other items issued by various publishing houses.

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Prof. D. Tech. A.I. Mikhailov, Director
The Institute of Scientific Information
USSR Academy of Sciences
Baltijskaja ul., 14
Moscow A-219 USSR

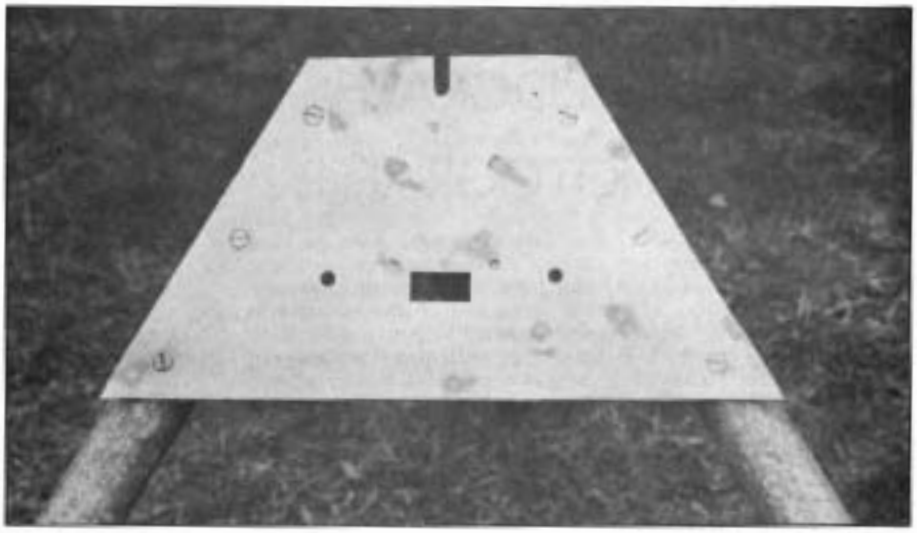
— *Okay, it's done. You're on our mailing list.*

"Off-Axis" Defined

Dear Mr. Berry / In TM #5, Thomas Dessert refers to his guidescope mounting mechanism as an "off-axis guider mount." Mr. Dessert is to be congratulated on a fine article that showed some good ideas. However, I would feel remiss in my duty if I left his description uncorrected: A more accurate way to describe his mount is "an improved adjustable guidescope mount." Off-axis guide systems use peripheral light from the main image to produce a second (guide) image, usually with no reduction of light to the main image. Off-axis guide systems usually also rotate around the axis of the main image to "sweep" for a guide star.

As with Mr. Dessert's improved adjustable mount, it is much easier to locate a guide star with the off-axis system "sweep" than with the traditional guider support rings and screws. Mr. Dessert provided a stronger structure that reduced the flexure. 39►

Tripod for a C-8 Dynamax



When I ordered my C-8 I knew that I wanted it to be easy to set up, convenient for my youngster and neighborhood children to look through, and not require me to spend the whole evening standing up. To meet these requirements, I designed and built my own tripod to support it. The dimensions and parts were chosen partly by part design and partly by whatever was handy. You can use the same precise techniques.

The height was to be about three feet to accommodate little stargazers and to allow me to use a folding chair for most viewing. The low height will also permit me, hopefully, to drape a bit of mosquito netting over my head and arms for less hectic summertime viewing.

The legs are 1½" water pipe. Two of them, set at about 60° apart, are 51" long and attached to the telescope mounting plate with ¼ x 20 flathead machine screws. The third leg, which threads into a floor flange on the back of the plate, is 44" long. The 44" length nominally sets the polar axis at about 43° on a level surface.

I really wanted to use ½" aluminum plate for the telescope mounting plate, but backed off to ¼" because ½" was impossible to scrounge, and then ended up using two thicknesses of ⅛" plate because it was free! I only had to plug a few unwanted screw holes with epoxy after assembly. Don't use material any thinner than ¼" for the mounting plate because it won't be rigid enough for the 30-odd pounds of legs and 20 pounds of telescope it will have to carry.

Because I was stuck with using ¼" material for the mounting plate, it was necessary to saw about ⅜" off each of the telescope's mounting bolts to keep them from bottoming in their threaded holes. With half-inch plate, this shouldn't be necessary. A couple of coats of white Rustoleum (put on after the pictures were made) finished off the mount.

James Bailey
Sussex, WI

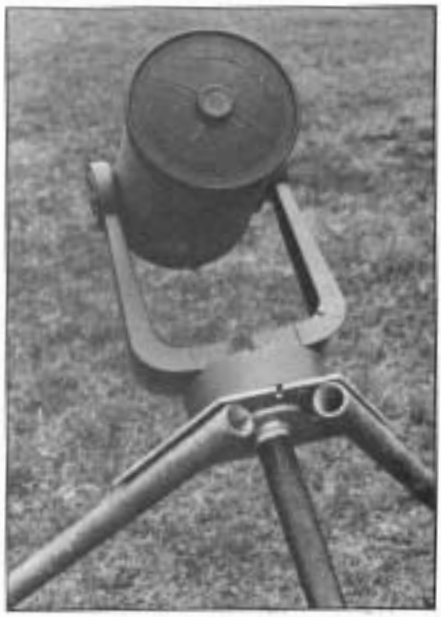


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photo by Jack Newton

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Letters

An off-axis system will also eliminate the flexure and sagging secondary mirror problems without the extra major craftsmanship displayed by Dessert. Because the off-axis' two images are of the same optical system, any wander of the main image is also seen in the off-axis guide image and can be corrected for. As R. Provin & B. Wallis pointed out, "After poor guiding and tube flexure, sagging of the secondary mirror is probably the most common cause of trailed star images."

Off-axis systems also avoid some of the problems that Mr. Dessert had to solve:

1. Off-axis provides a long enough focal length to easily allow high magnification in the guide images.

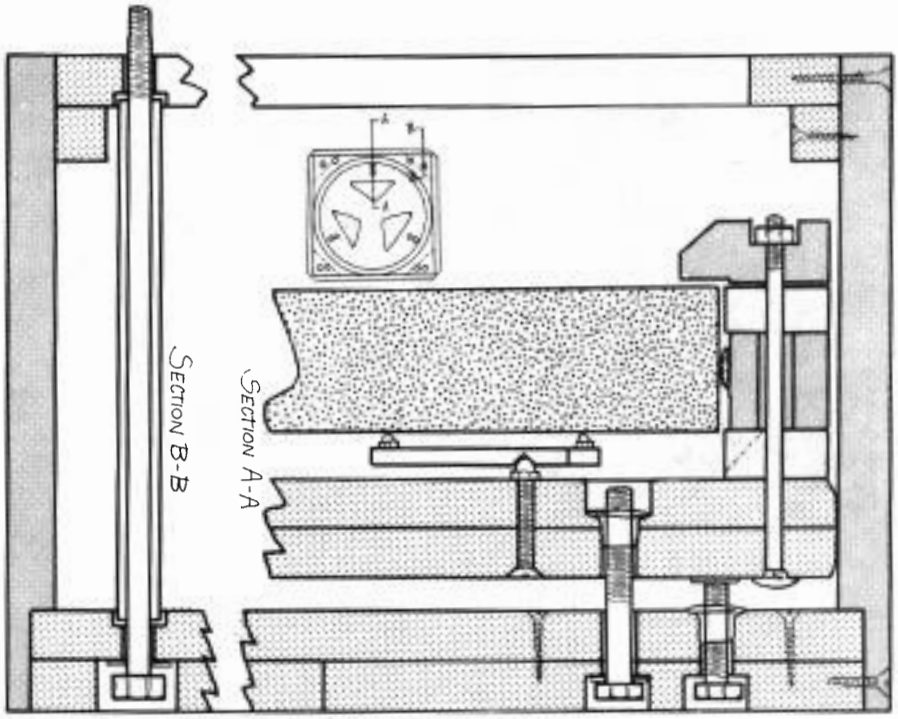
2. The eccentric extra weight (that required another 15 pounds of counterweights for Mr. Dessert) is minimized...only 2.5 pounds for my "Visable Guider."

3. The cost and mechanical factors do not limit effective size of the guiding systems' light capacity. How much light is obtained by the off-axis' guide image depends upon several factors including f/ratio, size of the diagonal mirror, and how far off of the main optical axis the guide image is located. As a general rule, an off-axis system will provide from 25% to 60% of the main telescope's light capacity to the guide image. The result is comparable to a 5" to 8" guidescope on Mr. Dessert's 10" main scope.

I believe that it would be beneficial for all of us astrophotographers to use the term "off-axis guide system" with the meaning that I described above. It clearly is a different concept from the "non-parallel piggyback guidescope."

While others and I believe that the off-axis approach is better, we do not intend to break the arms of our piggyback guidescope counterparts. Indeed, once we can get the meaning more clearly defined, there will be better debates over cups of coffee.

Thomas C. Venable
6111 Fifth Avenue
Pittsburgh, PA 15232



Several readers asked for a cross section of the mirror cell for my 20" Dobsonian described in TM #7, page 24.

Springing a Mirror

Dear Mr. Cox / Your article "Better Mirror Cells" in TM #6 is certainly an important and timely subject and it offers the result of a lot of experience. You put your finger on a big source of "un-adjustment" — looseness that causes the adjustment nuts to turn. The big photo shows a weak or flimsy spring, too large and stretched out.

I have always found that three spring-loaded bolts give a desirable push-pull action and, properly employed, are reliable. Always select a spring just big enough to fit smoothly over the bolt and not compressible to less than 50% of its extended length. Figure its cut length no less than 150% of the expected space it will fill compressed.

Certainly locking nuts are necessary, and I have used them over the wing nuts on all exterior adjustments for my TCTs. T-nuts which have their prongs clipped off and their other face molded with epoxy into a knob provide a reliable locking nut.

The meridional adjustment is the most active one on the schiefspieglers — it is the sagittal adjustment that is confusing and needs the simplification offered. I intend to use it in a future arrangement.

A.L. Woods
603 Laven-Del Lane
St. Louis, MO 63122

40►

Letters

◄39

Dobsonian Popularity

Dear Mr. Berry / Thank you for publishing Ben Mayer's interview in ASTRONOMY, and Bob Kestner's two articles in TELESCOPE MAKING. Quite a number of people have called or written to tell us how much they liked them.

We have referred a good number of people to TELESCOPE MAKING #4 and #5. I hope you have plenty of stock.

John Dobson
The San Francisco Sidewalk Astronomers
1600 Baker Street
San Francisco, CA 94115

— We do; in fact we went back to press with TM #4! It was this demand that led us to bring out the "How to Build a Dobsonian Telescope" reprint booklet of articles from TM.

Solar Dobsonians

Dear Mr. Berry / The enclosed article was in my local newspaper. I don't know whether or not you have seen it. The article brings up two interesting subjects:

1. Dobson's method of observing the Sun. What exactly is he doing to accomplish this?

2. How does one go about obtaining, making, whatever, a partially reflective surface that will allow the passage of just the right amount of sunlight for safe eye observation and picture making?

Hope the article is useful to you. I thoroughly enjoy TM! Keep up the good work!

Jerry Misner
Another California ATM!

— He has a partially aluminized sheet of plate glass (selected, of course) at a 45° angle that acts as a sunfilter and partially reflecting diagonal at the same time. The primary is also not aluminized. If the solar filter gets broken, or falls off accidently, the diagonal is simultaneously removed and no harm comes to the observer. Getting the right coating is simply a matter of asking the aluminizer for a 0.1% transmitting film on the glass — this costs a bit more because they have to monitor it.

League Survey

Dear Mr. Berry / There are 7,000 amateur astronomers who belong to the Astronomical League. Of those, only 180 saw fit to complete and return the questionnaire in the August 1979 REFLECTOR. Even with such a small percentage of the League membership responding, the results pointed out the need for a committee to closely watch out for the interests of the amateur.

A member from Des Moines, Iowa made this point very clear when he wrote: "I see a need for truth in advertising for astronomy-related products much the same as was needed in the Stereo Industry back in the 60s. There are an awful lot of false claims about products permeating all or nearly all the ads seen today. It has to be stopped."

His main complaint, along with many others, was the inability of the companies to deliver their products on time. Also, customer service or the lack of it ranked right up there with false advertising and late shipments.

The companies receiving the most complaints were: Cave Optical Co. with 35 complaints for late shipping, poor customer service, and alleged false ads; Criterion with 24 complaints for late shipping, ads, and poor customer service; and Coulter with 10 complaints for late shipping. These three companies showed the least amount of concern about resolving their problems. Other companies, such as Edmund, Meade, OTI, Celestron, and Jaegers, received between three and five complaints each, but they attempted to resolve the problems to the satisfaction of their customers. They usually went out of their way to do so. Tuthill and Parks received three complaints each because of poorly manufactured products such as dewcaps, solarscreens, and telescope tubes. University Optics had five complaints for late shipping, and a number of other companies received only one complaint each. Even the League received two complaints for late shipment of books and the *Astronomical Calendar*.

The types of products receiving the lowest ratings were: eyepieces supplied by manufacturers with their telescopes, eyepiece solar filters and mountings on some small Japanese refractors, and pedestals on many Newtonian reflectors. Also, clock drive systems on most telescopes were rated as inadequate for astrophotography requiring long exposures. This was also the main complaint about mountings and pedestals. They were considered good for observing, but a little shaky for photography.

Probably the two items receiving the best ratings were the optics of most telescopes made in the U.S. and the professional or research grade erfles and orthoscopic style eyepieces. Accessories and coatings by most manufacturers were rated average to good.

We have not tried to single out any one company as being the best or worst. We feel that no company is all bad or all perfect, but that they all should work harder to improve their products and service. Though three companies have shown an inability to handle customer relations properly, they do offer some better than average equipment.

However, there were some companies who did receive a high number of endorsements from the members replying. This is not to say they do not make any mistakes, but when they did, they attempted to correct them.

For those wishing to shop around for new equipment, here is a list of the favorites: Edmund, Meade, Celestron, Novak & Co., Vernonscope, and Unitron. The best dealers to purchase books from might be: Sky Publishing, Herbert Luft, and Vintage Book Co. Remember, these are only suggestions made from the comments received through the survey. Study them carefully and remember the old saying "Let the Buyer Beware." Hopefully, we can change that to "Let the Seller (Astronomical Companies) Beware." It is time for the amateur astronomers to stand up for their consumer rights.

Tom Reiland, Past Chairman
Product Quality/Safety Committee
Astronomical League

— Thank you for sending us your report.

Mail Order Business

Dear Sirs / After building a 10" reflector and having dealt with various companies in the telescope supply business, I would like to pass on my experiences to other ATMs in the hope that they can avoid some of the pitfalls that I have encountered.

Since the majority of suppliers are located in California, one of the major headaches comes from having parts shipped from there to the East Coast. I would highly recommend using UPS since they are much better in service than the U.S. Mails. Air UPS is not always better than ground UPS shipments — for example, lenses (eyepieces, filters, barlows) can be affected by moisture if they are shipped by air. The low air pressures can cause air to be evacuated from between lenses and when back on Earth again, moisture-laden air may be sucked into the partial vacuum leaving moisture trapped inside. Also, ground UPS is a lot cheaper than air, although it involves a longer wait.

By the way, in dealing with mail order firms, consumers should be aware of a federal law: the company must notify you within 30 days if they cannot fill your order. Then you have a choice between asking for a full refund or waiting a longer period of time. It doesn't take very long for a company to receive a bad reputation.

R. Fadderr
Fort Lee, NJ

Enthusiasm

Dear Mr. Berry / Great job on TM #4 and #5! The material on Dobsonians answers all our needs on mountings for the new interim January classwork. I have made five mountings so far, three for 4¼" scopes used by our school for gifting, a unit for a 6" mirror and one for a 10" system. Incredible units deserving far more use! I use nylon chair tip glides: cheap and available. Telfon's o.k. but hard to get.

Sherm Schultz
St. Paul, MN

— Sherm: You should try to get teflon-coated tacks (used on drawers in furniture) rather than nylon. Also try teflon-coated sticky tape. Teflon is better than nylon.

It Worked!

Dear Sirs / Enclosed is a photo of my 10¼" f/5 telescope which was made with the help of TM #5. I used a Star Instruments mirror, diagonal, spider, plus a Meade 8 x 50 right angle finder and 2" focuser.

The mount is stable and works perfectly just as you said it would, and it's a real pleasure to use. Even at 300x there is no vibration and it's quite easy to keep objects centered in the field of view.

Four side bearings were used and the focuser is rotated about 20° from the center line of the side bearings to allow different eyepiece heights for difficult size viewers by rotating the tube 90° in either direction.

This was my first attempt at building a telescope and it was very enjoyable. The only thing that presented a problem was how to get the wax off of the Sonotube. I discovered that the inner and outer layers could be peeled off about the thickness of this paper along with the wax, leaving a good surface for painting.

My total cost was under $350 with all optical parts off the shelf from Star Instruments of California and also the 8 x 50 Meade finder.

I found teflon available from the Boeing Aircraft Surplus store in Kent, Washington. One third of a square foot cost me $1.

Again, it was a very enjoyable first telescope making project. My thanks to you people and Mr. John Dobson for your efforts! And thanks for your excellent publication — I am looking forward to the next TM.

Gerald Sibert
11807 34th Ave. E.
Tacoma, WA 98446

— Mr. Siebert's telescope was shown in the June 1980 issue of ASTRONOMY, and is once again pictured here. It's nice to know you've helped people!

High Tech Comment

Dear Mr. Berry / I just discovered your magazine thanks to a friend who had an extra copy of TM #5. I would like to subscribe to your publication and at the same time would like to make a few (hopefully) helpful suggestions.

First, if you made some of the overly large photos a bit smaller, more room would be left for technical details, technical photos, and technical drawings.

Second, I know that Andy Tomer's telescope was not a featured article, but a lot more information could have been provided. The goal of a reporter in the field should not be to think what makes a pretty pier, but rather he should be thinking details, details, details...

Third, please do not let this magazine become one big Gleanings article because there's no way I would pay 2 bucks an issue for it. Don't just show us pretty pictures — tell us how and probably more important, WHY something was designed a particular way. We're interested in WHY a component met certain qualifications for WHAT particular need in either a mechanical or electronic application, which leads us to my next suggestion.

Fourth, never, never give the excuse that we, the readers, do not understand technical details. If you tell us WHY a certain transistor met a certain application then we will have the understanding and knowledge to substitute more readily available parts.

Fifth, remember details, details, details...

Rick L. Crockett
P.O. Box 505
San Marcos, CA 92069

P.S. I am working on a 22" and will soon be looking for larger blanks. The machine I built will handle up to 48". Will build larger machine if required and will consider trading optical work for blanks, etc.

— Thanks for your comments. I hope that authors will take Mr. Crockett's suggestions to heart and provide more of those details when it's appropriate.

Photographs often contain significant information that is lost if they aren't run large. While I can't defend every single photo choice we've made, I think most times we've run big photos it has been justified. Certainly whenever an author supplies blueprints, cutaway drawings, and all the technical details, we run them. You will be pleased to hear that Andy Tomer, who now lives out West and attended this year's Riverside, is writing an article on his telescope which will appear in a future issue.

The only time we have ever even suggested something was too complex for treatment in TM was in reply to the ray-tracing query by Phillip Trosko in the TM#5 Letters column, where we (I think, sensibly) referred him to two books totaling, between them, over 1,000 pages. Meanwhile, we're waiting for an author to write that masterpiece!

Thanks again, because I think you've brought up some very important points.

Teflon Letter #1

Dear TM / Please help! I can't find any place that can supply teflon pad material for the bearings of my 8-inch alt-azimuth reflector. What type of firm carries it and what is its commercial application? Is there any mail order source that you know of?

I have been using the hard nylon chair slides sold for tacking to the legs of chairs and have had some luck, but this isn't very smooth.

Keep up the good work on TELESCOPE MAKING. It's just what we've needed.

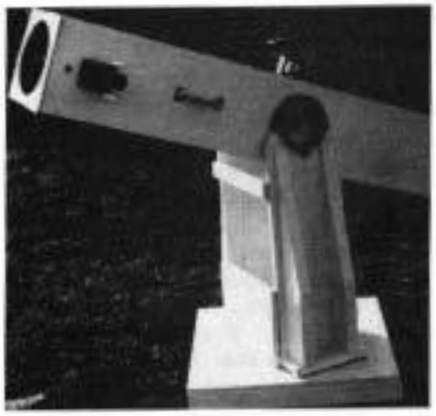
Charles Bradley
Box D-695
White Sulphur Springs, WV

— Mr. Bradley was advised to try "Plastics, Rods, Sheets, and Tubes" in the Yellow Pages. This is the basic advice that seems to work everywhere.

Teflon Letter #2

Mr. Berry / I just wanted to thank you for your speedy reply to my questions about teflon bearing material. As you suggested, I found a supplier in a nearby big city Yellow Pages, and one phone call arranged my order. After I mailed a check, I received the teflon in a week.

I had started this scope about two years ago, but never finished it because I was "in over my head" trying to mount it equatorially. When the first articles appeared showing the trend toward stable alt-azi mounts that were easy to build, I immediately set to work. Since installing the teflon, the scope performs just as advertised and it gets used a lot more than it would have, were it hard to set up. So I am really pleased.



Enclosed is a photo of it. As you can see, it isn't really a Dobson mounting because I started it before the "how-to" article appeared, but it still works great.

Once again, thanks.

Charles Bradley
White Sulphur Springs, WV 24986

Electronics

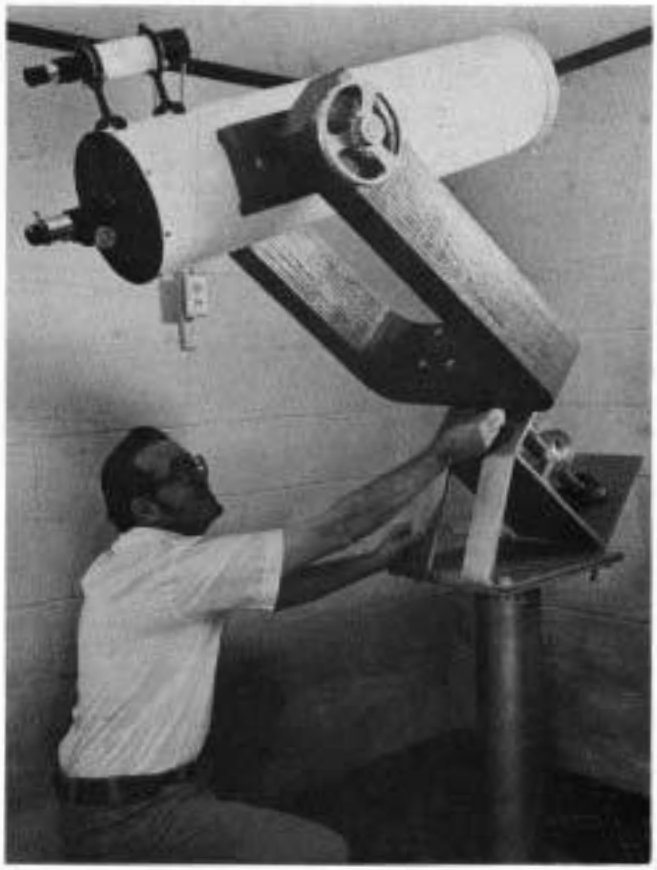
Dear Mr. Berry / I thoroughly enjoyed Russ Genet's article on photoelectric photometry in TM#7. I was pleasantly surprised to learn that there are other amateurs using microcomputers as an observing aid; and it's encouraging to note that electronics technology is finding its way into a broad range of applications in amateur astronomy including photoelectric sensors, telescope guidance, and data processing. More articles on these subjects in your magazine would be heartily welcomed.

I must also extend a belated thanks for mention in TM #4 of the CID camera developed by the San Jose Astronomical Association. I have since moved from California and purchased my own CID camera which will be developed in parallel with the device operated by the San Jose group.

Peter L. Manly
1533 W. 7th St.
Tempe, AZ 85281

— TM is pleased to solicit articles on electronics projects, microprocessor application to telescopes, computer programs for telescope control, and so on. *See the editorial on page 3.*

A Fork-Mounted 8" Cassegrain



My first reflecting telescope was the traditional 6-inch f/8 on an equatorial mount. From the mirror and its cell to the pedestal and clock drive, it was assembled entirely of commercially available components. This approach to telescope making acquainted me with the workings of a Newtonian and the high quality of telescope parts available to the amateur today.

The 6-inch telescope has served well. However, here in the northeast, frostbite could result by the time the telescope is set up and aligned, a definite disadvantage to serious observing. I soon began to dream of a permanently mounted telescope in its own shelter, a dream I would expect of any amateur who lugs a large Newtonian in and out of the house for each observing session. The telescope described in this article is the first step toward that end.

Quite simply, it is an 8-inch f/16 Cassegrain on a fork mount. A pier arrangement of pipe and steel plate houses the clock drive and provides a stable mounting for the completed telescope. The mirrors are by Cave and are supported by Novak mounts in a fiberglass tube. The mirrors have contributed to the greatest cost of the project thus far. An amateur who can grind his own will realize a substantial savings in this area.

In designing the mountings, two requirements had to be met: first, that the mounting provide a rigid support for the telescope, and second, that it be flexible enough in design to allow future modification as my requirements and interests change.

The keystone of the mounting is the drive unit shown. It houses the polar shaft, bearings, and clock drive. The elevation of the polar axis is fixed for my location; however, adjustment is available in a push-pull bolt arrangement when the unit is mounted on the pier. This adjustment allows correction of fabrication or installation errors.

The polar shaft is supported by flange-mounted bearings which are considerably less expensive than the pillow block types commonly used in other designs. A flange is welded to the end of the polar shaft for connection to the yoke. The drive motor is by Schmidt Associates, and there is plenty of room for inclusion of drive correctors and electronics as they become available. This drive unit satisfies the second requirement of the design. It can be mounted to any height pier or adapted to various types and sizes of telescopes.

The pier is a piece of 6" pipe with two square steel plates welded to each end. Its height was selected for convenient operation of the 8" Cassegrain. When bolted to the foundation, it, along with the drive unit and yoke, provides a rigid support for the completed telescope, satisfying the first requirement of the design.

The yoke is a laminated assembly of plywood as described by Bruce Lundegard in his article in the January 1976 *Sky and Telescope*. The seven layers of ¾" thick plywood are glued and reinforced with ½" diameter bolts. The cleats which are used to mount the telescope tube to the yoke are also constructed of laminated plywood with 1" diameter steel shafts epoxied in place. The shafts are supported by ball bearings which have been epoxied into recessed holes in the yoke.

With the exception of the polar shaft machining, the telescope was built using hand tools and the resources of a well-equipped woodworking shop. After drawings were made of the drive unit, pier and shaft assemblies, several small welding shops were approached for quoting purposes. I was fortunate in getting the complete weldments including material for a pittance. Possibly they were just glad to get rid of me, but I think everyone gets intrigued by working on a telescope beyond the department store reflector.

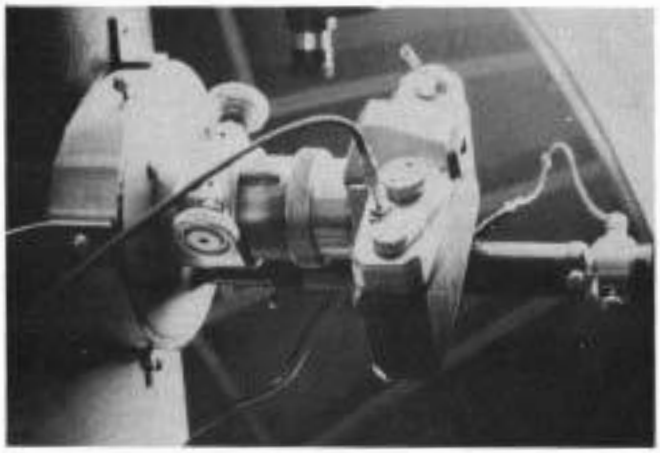
Ron Bukowski, a friend with the woodworking shop, was of great assistance in machining the pier and drive unit. His drill press and bandsaw were indispensable in cutting the yoke parts.

In conclusion, you can build a high performance telescope and in doing so gain the following:

1) a unit constructed of the highest quality components you can afford,
2) a sound understanding of how it works,
3) ability to modify as experience grows, and
4) satisfaction that you did it yourself.

I would be glad to correspond and exchange ideas with other amateurs who are undertaking such a task. Now, out to the backyard and the groundbreaking for the observatory.

Robert C. Reisenweber
3621 Ridge Parkway
Erie, PA 16510



A Guide-Focus Unit

Over the years this author has tried several methods to improve guiding. A 3" f/15 guidescope was initially used in conjunction with a 3x Barlow and 12 mm eyepiece. This system worked reasonably well, that is, 2/3 of the photographs taken under 20 minutes had very little guiding error. However, the longer the exposure, the more likely guiding would deteriorate.

Internal flexure through the primary optical train seemed to be the culprit. Something was shifting or flexing between the main and guiding telescopes. The mirror cell for the 12.5" was secured in position with bolts through the back of the telescope. This would eliminate any shifting of the spring loaded main mirror during the time of the exposure. The diagonal was also locked in position in a similar manner. Did it help? No! The flexure was still there. I finally concluded that the 14" diameter ⅜" wall sonotube which supported the main telescope must be sagging. The only cure to permit this type of guiding was a metal tube. But a steel tube would have tripled the weight of the telescope and this seemed impractical.

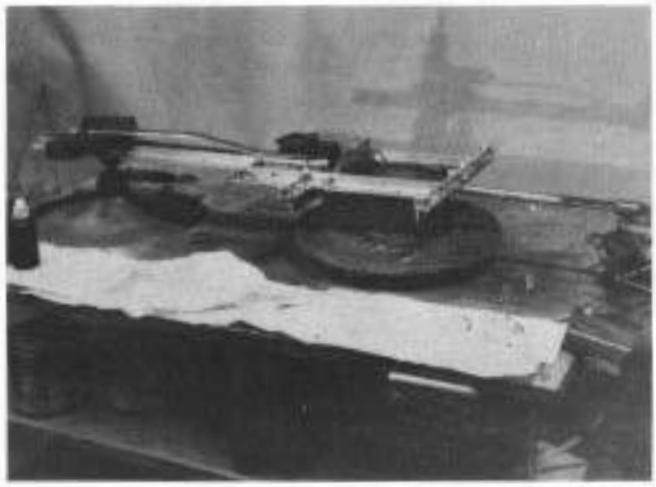
An alternative solution would be to design a system to guide on the image from the main mirror. I mounted a small prism in the wall of a 2" draw tube, along with a Barlow lens and star diagonal, just below the camera. This system worked very well when a bright guide star could be located next to the object being photographed. M-51 was my first target. I found out quickly that very few of the Messier objects have stars of sufficient magnitude for guiding adjacent to them.

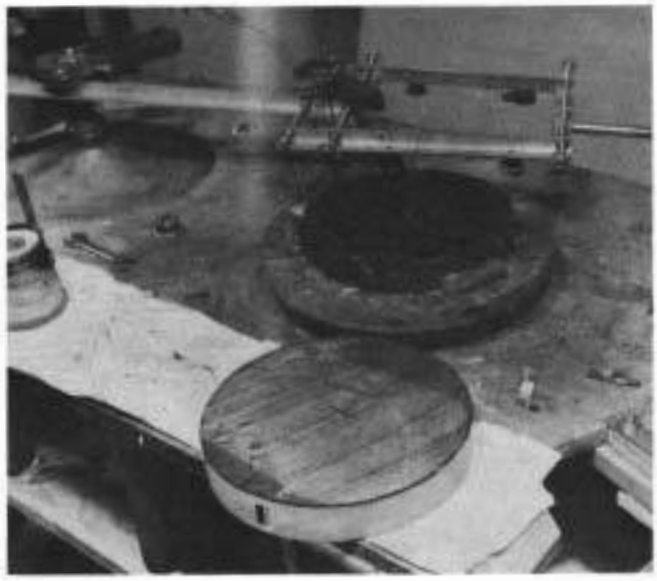
What was really needed was a guiding head that could pick up virtually every star from the center of the field to the outer edge. This could be accomplished by constructing a rotating platform for the focuser, with enough room around the perimeter for a set of prisms to scan the entire field for guide stars. A 5" inside diameter pipe was machined to accept the platform. The focuser was mounted in the center and a hole machined to hold the prism assembly next to the focuser.

The prisms can be pivoted in a semicircle and also be rotated around the field by rotating the platform, virtually covering every star in the field, although in most cases stars outside the photographic field are used for guiding. This cuts down on diffraction caused by the prisms interrupting the light heading for the film.

The new guiding head has been in operation for one month now and has provided acceptable guiding for the first nine photographs attempted. Now that I am batting a thousand, the time spent at the telescope will be far more productive.

Jack Newton
4204 Morris Dr.
Victoria, BC
CANADA V8X 4G8





A Polishing Machine

I've learned the advisability of polishing mirrors well away from the grinding stand, so when it came to building a machine to do some of the work, I designed a machine just for polishing.

Since my mirror making has been limited to 8-inch or smaller, I chose a Hindle-type machine with "works" constructed from the base and gearbox of a salvaged Maytag washer.

Wooden arms drilled for variable positions and easy lubrication, and an adjustable cradle made from aluminum angle extrusion, provide for 4¼ to 8-inch size mirrors.

The rotor oscillates the crank arm through about 200° and gives 54 complete strokes per minute. A small turntable motor gives about 15 zigzag sideways strokes per minute and also drives a rotating table for a bottom disk at 1⅛ r.p.m. The rubber bumpers on the cradle rotate the upper disk in the opposite direction at a variable rate adjusted about 1 r.p.m.

Polishing time is somewhat longer than when the work is done by hand, but this is balanced by good surfaces with less trouble on turned-edge problems. Hand figuring is done on the turning table.

A. L. Woods
603 Laven-Del Lane
St. Louis, MO 63122

What's New?

TCT "Lens"

Mákowsky KATOPTARon..."the only all-mirror optic with 500 mm focal length for use with SLR cameras," says the blurb. Adjustable f/stop f/8 to f/32; no central obstruction, no color error, no vignetting, built-in sunshade. Device has a 23° angle between aiming and viewing, f.o.v. is 5°, regular model focuses to 16 feet, model TS macro version to 6 feet. "Color and contrast of extraordinary quality," Zerodur mirror blanks. Made in West Germany by META-Geratechnik in Koln. Lists at $775.00.

Scientific Instrument Division
Silogram Photo-Optical Corp.
2065 30th St.
Boulder, CO 80301

Commercially-Made Dobsonian

Odyssey 1 — "Classical Dobsonian Alt-Azimuth mount featuring the construction desired in this type of mount." 13.1" aperture by 1" thick primary, f/4.5; 3.1" minor axis diagonal, incl. 25 mm Kellner eyepiece. Tube less primary, 70 lbs.; rocker assembly, 55 lbs.; mirror, 10 lbs.; max height, 74"; max height of focuser, 62"; tube length, 61" but can be shortened. $395 plus $75 crating plus FOB Riverside, unless picked up at the factory.

Coulter Optical Co.
POB K
Idyllwild, CA 92349

Big Mirror

17.5" f/4.5 thin mirror (1½" thick) Pyrex Newtonian primary mirror and diagonal, null figured, aluminized, SiO overcoated; 26 to 29 lbs.; 4.25" minor axis secondary, octagonal, 1/8 wave; must be used on 9-point support. $595.00 postpaid, insured in USA.

Coulter Optical Company
POB K
Idyllwild, CA 92349

"Ultimate Astrograph"

Self-contained 5.7" f/1.7 hybrid Maksutov-Cass; seven elements, 2 mirrors plus 5 refractive elements; f.o.v. is 7° or 35 mm; 10" length o/a, 6" diameter; 8 lbs.; factory set on infinity (but adjustable) focusing; uses 35 mm film in cassettes, adv/rew knobs; film held flat against glass plate for flatness. $995.00 postpaid and insured in USA.

L. Henzl & Assoc.
215 West Leroux St.
Prescott, AZ 86301

Large Mirror Blanks

16" to 24" Pyrex blanks, molded, thin, lightweight (i.e., truncated conical shape), delivery 1-2 months. 16", 35 lbs., $500; 20", 40 lbs., $800; 24", 60 lbs., $1200.

Star Instruments
17972 Sky Park Circle
Suite K
Irvine, CA 92714

Aluminizing

Aluminum coatings with silicon monoxide overcoating for telescope mirrors; prices run $1.50 per inch up to 14 inches plus $3 to remove an old coating. Secondary coated with primary for free. Include postage and insurance for return shipping.

ATM Coatings
16105 Via Paro
San Lorenzo, CA 94580

Massive Mounts

The 12-HD is a massive mount with 2" stainless-steel shafts, 4½" cast 6061 aluminum housings, Sealmaster ball bearings on both axes. 25" cast cradle, 10" circles, precision leveling pads, 8"-diameter aluminum column. 10" sidereal rate drive from 60Hz line, 60 micro-inch lead variation tooth to tooth; tangent arm dec. drive 10" radius, precision lead screw and follower. Wow! Price on request.

Telescope World
26625 Mission Blvd
Hayward, CA

Volkscope

"...an intelligent alternative to the gimmick-prone telescopes that abound today." A 12" f/4 telescope (70 lb.) on a lightweight (30 lb.) knockdown alt-azimuth platform; scope can be placed on an equatorial mount later..."start large but simple; upgrade to a photographic mounting later if needed." Fiberglass tube assembly, 2" focuser, sliding counterweights, 50 mm finder or telrad finder. $995.00.

Astroscopics
5617 Hawthorne St.
Montclair, CA 91763

Filter Adaptor

QUIK-Change filter adaptor is a machined tube with a slot in the side; allows you to use photo filters with standard 1¼" eyepiece, adds 1½" to focuser height. Good for nebular filters, etc. Stock 42,803 $39.95 plus $2.50 packing and delivery.

Edmund Scientific
Barrington, NJ 08007

Lens Cleaner

Amertec OpTec 2 is a fancy lens cleaner for laser optics. "Removes all traces of fingerprints from high technology optics, thus preventing etching and damage to these expensive lenses." May be used on glass, hard resins, mirror finishes, mounted optics; removes oil, dust, calcium, and carbon deposits. (!) Anti-static, anti-fog. Might be super-good for eyepieces. Available in small spray bottles and one gallon bottles for industrial use. No prices given.

Phil Schreiner
Amertec High Performance Products
Dept. OPR-1
10471 Broadview Place
Santa Ana, CA 92705

Folded Refractor

Complete tube assembly or as individual components; 10" includes lens, three optical flats made of Zerodur, high refl. coatings, rack and pinion focuser and one eyepiece, tube length 64", e.f.l. 166", diameter 16". 6" is 29" by 10.75" o.d., e.f.l. 60". O/A light transmission 80%; 6" f/13.3, $1,250; 10" f/16.6, $6,200.

R. E. Brandt Lens Works
Oak Knoll Drive
Prescott, AZ 86301

12" Maksutov

12" convertible Mak/f/4.4 Newtonian — Mak/f/20 Cassegrain system, interchangeable secondaries; Cass. obstruction 22%, aspheric corrector lens; Newtonian focus gives 1.4° f.o.v.; Cass 10' f.o.v.; tube 15" o.d. by 53 length. $7,200, also available in 8" and 10" versions.

R. E. Brandt Lens Works
Oak Knoll Drive
Prescott, AZ 86301

Fancy Eyepiece

The TeleVue Optics Nagler 13 Eyepiece (patent pending) has a 13 mm focal length and an 82° apparent f.o.v.; claimed to be exceptionally sharp even at extreme field angles, able to handle f/4 beam. 27 mm eye lens, 15 mm eye relief. Length overall: 5.5", diameter 2.45", weight 24 oz. $250.

L. Henzl & Assoc.
215 West Leroux St.
Prescott, AZ 86301

Massive Mounting

Model 1620 equatorial, polar and dec. housings, steel, 6" o.d.; shafts 3", aluminum; bearings 6" Timken roller, 4 each; drive, R.A. 12" Beyers, Dec. 18" tangent arm; saddle 8" wide by 36" long; dual axis, joystick controlled, v/r corrector, oper. from 12 VDC or 115 VAC. $2595. Options: fast positioning drive (up to 16x faster rate), $250; digital setting circles (1 min R.A., 0.2° Dec.), $395. Smaller mounts also available: Model 1012, $1595.

Teledrive Company
840 N. Fine Ave.
Fresno, CA 93727

Byers Mounts

"We have recently completed our long-term obligations to NASA and the U.S. Government, and we can once again offer you the world's finest astronomical driving systems and telescope mounts," says the product flyer. Six mounts in two lines "soon to be introduced" will offer equatorial platforms to carry fork-mounted telescopes (i.e., Celestrons) and German mounts for scopes up to 14". Prices will range $350 to "under $2,600." Gold anodized 2024 aluminum worm-gears, matching bronze worm, clock gears, and Hurst 100 in-oz synchronous motor. Write for price list on gears.

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